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ANNUAL REPORT
Segment I, July 1, 1990 to June 30, 1991
Illinois Department of Conservation Project No. F-112-R

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING

Illinois Department of Conservation
Dingell-Johnson/Wallop-Breaux
Research Program

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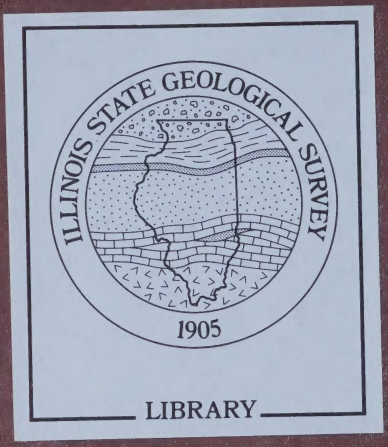
Illinois State Geological Survey
Champaign, IL 61820
August 1991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EXECUTIVE SUMMARY

This is a first year Annual Report for Illinois Department of Conservation Research Project No. F-112-R-1. The study was supported by funds made available through the Federal Aid in Sport Fish Restoration Act, administered by IDOC. The purpose of the project has been to provide information on the distribution of lake-bottom materials, water depths, and shore features in the Lake Michigan nearshore zone. The data are intended to serve as management tools for southwestern Lake Michigan nearshore and offshore sport fisheries. First year emphasis has been on Chicago area harbors and open-water nearshore areas. Included in the report are maps of five of Chicago's small boat harbors and two open-water nearshore areas, all showing water depths and distribution of bottom materials. Locations of these maps are shown in Figure 1.

Chicago's small boat harbors range in size from 16 acres to 48 acres. All are artificial, built by dredging and filling. The two southern harbors, 59th Street and Jackson Park are shallow, around 8-10 feet in general depth whereas the three northern harbors have general depths of 20 feet or more. Distribution of bottom materials is similar for most. Montrose, Belmont, 59th and Jackson Park all have organic silt and clay bottoms in their interior parts with sediments coarsening toward their entrance channels where gravel and exposed glacial till are common. In Diversey Harbor, materials are generally coarser, but silts occur in two deep basins of the main harbor. All of the harbors experience water circulation caused by high waves and by lake level variations. Most suffer low oxygen levels in their deepest parts during late summer (Savitz and others, 1990).

Two maps of the northern part of the Chicago shore were also prepared during 1990-91. Maps of northern Lincoln Park and of the Edgewater District show water depths and distribution of bottom materials. Most prominently shown is the littoral sand apron which attaches to the shore. It extends more than a half-mile offshore where it meets a sediment-veneered pebbly clay till bottom which extends further offshore.

Two additional maps in early stages of development are also included. A map of southern Lake Michigan shows general water depths as well as the locations of bedrock reefs that protrude through the glacial till. Another map, partially complete, shows littoral sand and glacial till in the Illinois Beach State Park area near the Wisconsin state line.

Some maps presented here are at scales that are not practical for research or field use. They are readily available, however, via computer plotter, at a variety of scales and combinations of data.

The maps, along with the narrative report, are the deliverable products for Illinois Department of Conservation Project No. F-112-R-1. They will be refined and new data added during the second year of the present project, IDOC Project No. F-112-R-2.

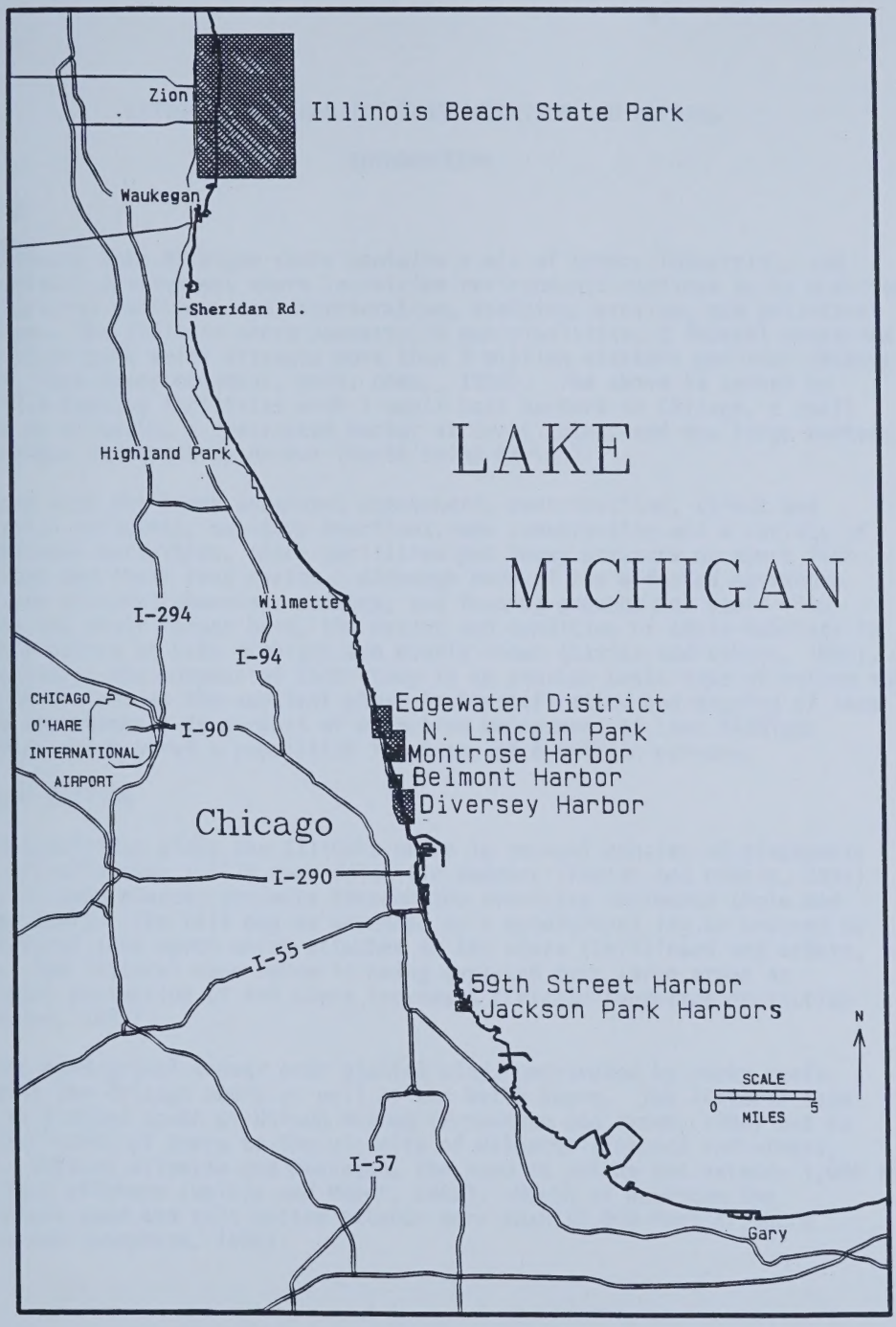

Figure 1. Index map showing locations of maps in this report.

INTRODUCTION

PURPOSE

The Illinois Lake Michigan shore contains a mix of urban, industrial, and recreational development where lacustrine environments continue to be modified by structural additions and deterioration, dredging, erosion, and pollutant discharge. The Illinois shore supports 14 municipalities, 2 federal preserves and a state park which attracts more than 2 million visitors per year (Robert Grosso, Park Superintendant, pers. comm., 1989). The shore is served by extensive boating facilities with 7 small boat harbors in Chicago, a small harbor at Wilmette, a restricted harbor at Great Lakes, and new large harbors at Waukegan and Winthrop Harbor (North Point Marina).

Combined with the human generated atmospheric contributions, street and industrial effluents, sanitary overflows, new construction and a variety of recreational activities, shore facilities put heavy pressure on sport fish resources and their food chains. Although many of the affected nearshore areas are critical spawning, nursery, and feeding grounds for sport fish species and their forage base, the extent and condition of their habitats in Illinois waters of Lake Michigan are poorly known (Savitz and others, 1990). Consequently, the purpose of this study is to provide basic maps of bottom and shore conditions as the earliest phase in identification and mapping of lake bottom environments in support of effective management of Lake Michigan fisheries which serve a population in excess of 6 million persons.

GEOLOGIC SETTING

Bottom substrates along the Illinois shore in general consist of glacigenic sandy gravelly clay (till) over dolomitic bedrock (Foster and others, 1991) which, in many places, projects through the overlying sediments (Holm and others, 1987). The till may be veneered by a sand/gravel lag or covered by the littoral sand apron which attaches to the shore (Colllinson and others, 1979). The littoral sand apron is being depleted over large areas as artificial protection of the shore increases (Chicago Shoreline Protection Commission, 1987).

The thin sand/gravel veneer over glacial clay, penetrated by rocky reefs, dominates the Chicago shore as well as the North Shore. The littoral sand apron is limited south of Wilson Avenue (Pranschke and Brown, 1988) but is extensive north of there to the vicinity of Wilmette (Shabica and others, 1991). Between Wilmette and Waukegan, the sand is patchy and extends 1,000 to 2,000 feet offshore (Welkie and Meyer, 1982). North of Waukegan the featureless sand and silt bottom extends more than 12,000 feet offshore (Somers and Josephson, 1968).

SCOPE OF THE PROJECT

The annual work plan for first year studies consisted of three job objectives:

Job 1 - Base Map Preparation

Objective: Preparation of base maps for plotting substrate characteristics data. The maps will show shore culture and land use, shore and nearshore protective structures, submerged structures and other relict features, water intakes and outfalls, ravine drainage outlets, street end drainage outlets, harbors and marinas with ramps and docks, fishing piers, bathymetry, and standard mapping grids.

Results: Base maps have been acquired, revised and updated for the Lincoln Park area, Edgewater District, Rogers Park District, Montrose Harbor area, Belmont Harbor area, Diversey Harbor area, Chicago/Monroe Harbor area, Burnham Park and the Jackson Park Harbors area. Bathymetry has been field mapped for southern Evanston. A base map has been made for the Wilmette area. Longitude/Latitude grids have been developed for all of the above but are not on the maps included here. Grid notation will be on all enlarged or other maps distributed outside of the Annual Report. Bathymetry has been acquired or developed for all of the above harbors. Land surveys have been completed and maps adjusted to them for Montrose, Belmont and Diversey Harbors. A land survey has been made for Chicago/Monroe Harbor but the map has not yet been adjusted. Partial land surveys have been made for north Lincoln Park, Edgewater District and Rogers Park District.

Job 2 - Mapping of Chicago Fishery Habitat Substrates

Objective: Map fishery habitat substrates of the Chicago shore area extending north to Kenilworth. Emphasis will be on mapping Chicago harbors, fishing piers, groins, and breakwater areas. Sidescan sonar will be used extensively. Bottom topography, sediment characteristics, hard bottom characteristics and special features will be mapped - spoil piles, rubble, submerged structures, algal mats, and significant textures.

Results: Substrates were mapped for Montrose, Belmont, Diversey, 59th Street and Jackson Park inner/outer Harbors.

Job 3 - Mapping Fishery Habitat Substrates-Open Shore Reaches

Objective: Map habitat substrate on the open shores, breakwaters, and revetments of the Chicago area northward to Kenilworth. This will involve Burnham Park, Lincoln Park, Edgewater, Rogers Park, Evanston and Wilmette. Mapping will include shore-edge riprap distribution, littoral sediments, clay bottoms, veneered clay bottoms, bedrock, dredge spoil, submerged structures, and special textures.

Results: Substrates were mapped for the area extending from West Gordon Terrace in Lincoln Park northward to Farwell Avenue in Rogers Park. Plans had included mapping as for north as Kenilworth but time precluded that goal.

Only the reach from W. Gordon Terrace to Devon Avenue was completed into computer plotted maps - two maps of the open shore: Lincoln Park and Edgewater District. Much area around Diversey Harbor has been substrate mapped.

METHODS

The maps submitted as products in this report consist of three main parts: a base map of shore features, contoured bathymetric data, and geologic maps of bottom materials distribution. The methods and equipment used to generate each of the above parts will be described in this section. Detailed information concerning the techniques, model, capabilities, and accuracies of equipment discussed below is contained in Appendix E.

BASE MAPS OF SHORE CULTURE

Base maps for the Chicago small boat harbors and both open-shore mapped areas were digitized from USGS 7.5-minute quadrangles and stored on a mainframe computer using ARC/INFO version 5.1 software. Illinois Department of Transportation high altitude photographs were mechanically adjusted to update shoreline features. Land surveys using a Lietz set 4 total station have been made for Montrose, Belmont, and Diversey Harbors, and the Lincoln Park map region, with others in progress so that base maps can be mechanically and computer-adjusted for increased accuracy. The base maps were produced and partly adjusted with support of USGS Southern Lake Michigan Coastal Erosion Study, Cooperative Agreement 14-08-0001-A0563, with additional adjustment and updating of shoreline features during this contract year with support of IDOC contract F-112-R-1.

BATHYMETRIC MAPPING

Bathymetric data were collected during several field seasons, using two primary methods and funding sources.

All harbor maps and nearshore (less than approximately 3000 feet offshore) bathymetric data in open-water maps north of Montrose-Wilson Groin were collected with support of USGS Agreement 14-08-0001-A0563 during summer 1988 and summer 1990, respectively. Depths were recorded using a Ross Model 803 hydrographic survey chart recorder. The readings were calibrated to water level using a graduated rod. Water surface elevations were determined from hourly readings at the National Ocean Survey Calumet Harbor lake gauge, and standardized to Low Water Datum (LWD), or 576.8 feet above sea level, International Great Lakes Datum (IGLD).

Prior to 1991, bathymetric profiles were recorded while the R.V. Alki, a 10-foot long inflatable dinghy, was kept on line by a shore-based transit operator, who communicated with the boat pilot primarily using hand signals. Offshore distances were determined using a Motorola Mini-Ranger system which uses microwave signals to measure distance to a shore-based transponder. Shore stations were located by direct measurement from known locations or during land surveys of each site using the Lietz total station.

Bathymetric data were also collected during 1991 with support of IDOC contract F-112-R-1. The primary differences in methodology between this data set and the previous one is that the R.V. Edgewater, a 19-foot Zodiac boat was used, with navigation and location data determined using an Apelco Loran-C positioning system.

After the bathymetric data were recorded, they were adjusted to Low Water Datum (LWD) as discussed previously, mapped, contoured at an interval of 1 foot, then digitized and plotted onto the base maps. The bathymetry for all harbor maps was generated under the support of USGS Agreement 14-08-0001-A0563. The processing, digitizing, and plotting of all non-harbor bathymetry was solely supported by IDOC contract F-112-R-1.

During 1988, 28 bathymetric profiles were recorded in Montrose Harbor, 39 profiles in Belmont Harbor, 38 profiles in Diversey Harbor, 14 profiles in 59th Street Harbor, and 42 profiles in Jackson Park Harbor. During summer 1990, 15 bathymetric profiles were recorded in the Lincoln Park map area, and 20 profiles in the Edgewater district map area. During summer 1991, 11 profiles were recorded in the Lincoln Park map area, and 12 in the Edgewater District map area. Index maps showing Bathymetric profile locations for all harbor maps and profile locations, dates, and areal coverage for both open-water maps are located in Appendix A, Figures 5-11.

BOTTOM MATERIALS DISTRIBUTION

The distribution of bottom materials on all harbor maps was primarily determined by directly sampling the bottom, either using a Petite Ponar dredge sampler, or using a home-made sampler consisting of a metal box on a long pole, which was primarily used from shore. All harbors were primarily sampled and mapped during June and July 1991, solely supported by IDOC contract F-112-R. Loran-C positioning was used to locate Ponar samples in Jackson Park, Diversey, and Montrose Harbors. Samples from 59th Street Harbor, due to its small size, were mapped by field estimation. Belmont Harbor samples were mapped using both field estimation and Loran-C locations. Sixty-four bottom samples were collected in Montrose Harbor, 54 in Belmont Harbor, 190 in Diversey Harbor, 28 in 59th Street Harbor, and 67 in Jackson Park Harbor. Sample locations in each harbor are shown in Appendix A, Figures 5-9.

Bottom materials for the open-water maps were also sampled using the Petite Ponar sampler, using Loran-C for positioning. Fifty-two non-harbor samples from the Lincoln Park map area and 25 samples from the Edgewater District map area were collected during summer 1991. Locations of these samples are shown in Appendix A, Figures 10 and 11.

Additional information used in these maps was provided by the bathymetric profiles from each map area. Characteristics of the profiles were used to infer bottom materials in two ways. First, different bottom materials reflect varying amounts of the acoustic signal which is emitted by the Ross chart recorder to measure depths. It was found that the littoral sand apron could be distinguished from exposed glacial till. Exposed clay-rich glacial till reflects a greater amount of the acoustic signal, creating a thicker, darker return with a distinct secondary (multiple) reflection on the chart recording,

while the littoral sand body absorbs more of the signal, leaving a thinner, less dark return with a less distinct secondary (multiple) reflection. Second, the morphology of the lake bed as shown on bathymetric profiles can be used to infer bottom materials, in that the littoral sand body has a smooth surface, while the till has an irregular surface. The two properties described above were confirmed by repeated bottom sampling in the map areas.

The collection of bathymetric profiles prior to 1991 was supported by USGS Agreement 14-08-0001-A0563. Collection of bathymetric profiles in 1991, as well as the interpretation of all profiles for bottom materials mapping was solely supported by IDOC contract F-112-R-1.

The final source of bottom materials data was sidescan sonar records, collected during 1987 and 1988 in an ISGS/USGS cooperative project. The collection and interpretation methodology for this data is described by Chrzastowski and Schlee (1988). Following the interpretation methods described by those authors, the sidescan sonar records were reinterpreted during the contract year using IDOC contract F-112-R-1 funds. It was found that substrates consisting of particles larger than gravel were identifiable. These substrates were primarily located directly abutting the shoreline, likely acting as toe protection for shoreline protective structures. Sidescan sonar data were available along the shoreline and in harbor mouths, but not in harbor interiors.

RESULTS

The plates contained in this report are examples of maps which may be produced from the computer database which contains the shore culture, bathymetry, and bottom materials distribution data that are presently available. The computer database is subject to revision as more information becomes available. Additionally, the format of each map has not been reviewed by ISGS editors, and should therefore be considered provisional and subject to revision. Reviewed copies of maps are planned as second-year products.

The size of the plates contained herein is constrained by the great demand on ISGS computer plotters. Larger copies of these plates can be generated, but in strictly limited quantities. Therefore, smaller copies of harbor maps were produced and duplicated on a color copying machine, limiting the maximum size of each plate to 11 x 17 inches. Due to their large size, open-water maps could not be reduced to 11 x 17 inches and were individually plotted.

MAPS OF CHICAGO SMALL BOAT HARBORS

Introduction

Construction of the harbors was begun quite early during the last century (Mayer, 1872). All are artificial, the oldest being Chicago and Monroe which achieved their essentially present shape in the 1890s. Jackson Park came next in the late 1800s to provide lagoons for the 1893 World Columbian Exposition. During the 1920s, Northerly Island, the present location of Meigs Field, as well as the shoreland west and south of it, was filled and became the site of the 1933-34 Chicago World's Fair.

Diversey and Belmont Harbors were constructed during the beginning of the 20th century. By 1909, the south lagoon of Diversey had been excavated (Keller and others, 1909) as part of a proposed canal which was never completed. Eastward from what is now Diversey Parkway, landfill had proceeded more than 1000 feet lakeward as well as northward toward Belmont. That fill formed the northern rim of Diversey and the southern fill of Belmont Harbor. By 1929 (USGS Chicago Loop Quadrangle, 1929), Belmont Harbor had been completed and Simmons Island had been constructed to form Lincoln Park Beach and the northeastern rim of Diversey Harbor. Montrose Harbor was constructed somewhat later than Belmont and Diversey but had its present configuration by 1929 (Young, 1932).

Most of the harbors were built by excavation and/or landfill and share the same characteristic steel sheet-pile and concrete bulkhead/seawall shore edges. In addition, all were largely constructed of lake bottom and shore materials which consist of silt and sand with little gravel so that they mainly have silty sandy bottoms.

As far as water circulation is concerned, all of the harbors share the ebb and flow of lake waters into and out of their entranceways. Wave heights of 4 to 5 feet are relatively common nearshore on the open lake. They drive harbor-mouth currents and raise or lower harbor water levels depending on wind direction. Barometric and wind seiches commonly change lake elevations by a foot or more and generate significant currents in entranceway channels.

All of the harbors were excavated and filled in natural sand and silt (Young, 1932) which overlie glacial clay till. The sandy sediments range up to 45 or 50 feet in thickness but in some places, where the harbors are excavated or deeply scoured, the glacial clay is exposed in the harbor bottom. At Diversey, Montrose, Belmont and Jackson Park Harbors, the till is exposed in the depths or in entranceway channels. Distribution patterns of sands and gravels indicate that they are strongly affected by current surges which flush fine sediments and leave gravelly lags behind. In some places, such as in Belmont Harbor, gravel and other materials have been dumped into the harbor. Boulders have been placed around harbor edges in several places perhaps to provide bank protection.

MONTROSE HARBOR

Montrose Harbor (Appendix A, Plate 1), the northernmost of the Chicago small boat harbors, lies south of the end of Montrose Drive covering 29-30 acres. It has an elongate oval shape oriented ENE. The jetty-protected harbor mouth is at the southwest end. The shore edge is protected by steel sheet-pile and concrete bulkhead/seawalls except at the harbor mouth which is protected by stepped stone blocks. The harbor-mouth jetties are of steel sheet-pile and concrete. The harbor measures more than 1900 feet in greatest length and 850 feet in greatest width. Floating star docks fill the eastern 3/4 of the harbor area. Fixed docks line the south side.

The harbor has a relatively uniform depth of about 20 feet LWD. It has a maximum depth of 33 feet just outside the harbor entrance, inside the protective jetties. A 15 foot deep sill exists just outside the harbor-entrance jetties. Inside the entrance proper, depths of 27 feet have been

measured. The bathymetry of the harbor entranceway may reflect erosion by harbor-mouth currents or dredging during harbor construction or maintenance. The harbor perimeter sides are steep, and there are no deep dropoffs.

Bottom materials in the harbor interior coarsen toward the harbor entrance. While most of the interior basin, some 17 acres, is floored by organic clayey silt, the remainder is floored mainly by fine sand and sandy silt. The protective jetties at the harbor mouth may act to baffle major wave and seiche fronts and restrict currents within the harbor, allowing deposition of fine-grained materials. The central entranceway consists of sand and gravel with an area of exposed glacial till in the deepest part of the channel. This suggests current-generated scour prevents deposition of fine-grained materials in this area.

Vegetation is essentially restricted to the harbor edges in a limited discontinuous way. Some deep water plants occur in the open depths and Chara sp. adheres to solid structures throughout the harbor and adjacent open shore land edges. Savitz and others (1990) list Chara sp., spiney naiad (Najas flexilis), Elodea sp., Myriophyllum verticillatum, flatleaf pondweed (Potamogeton robbinsii), Vasey's pondweed (Potamogeton vaseyi and Nitella sp. The last was found only in water 14 or more feet deep.

BELMONT HARBOR

Located between the street ends of Addison Street and Belmont Avenue, Belmont Harbor (Appendix A, Plate 2) is oriented elongate NNW/SSE, extending 3400 feet in length and 1300 feet in greatest width. It covers 53 acres. The harbor entrance is at the southeast and is open southeastward without protective jetties. The northwestern extremity is a 950-foot long narrow lagoon, a vestige of a proposed but incomplete alongshore canal. The shore edge is built of steel sheet-pile and concrete. The outer parts of the harbor entrance are protected by stepped stone revetments. Floating star docks are used in the northern end of the harbor while fixed docks are used along the east wall extending from south of midlength up into the north lagoon.

Harbor bathymetry records almost equal areas of shallows and deeps. A series of small basin-like deeps of 23-24 feet extends up the middle of the main part of the harbor. Along the west side, there extends a continuous shallow area 50- to 300-feet wide, with flats at the 0-5 and 5- to 15-foot levels, extending from the lagoon to the southern tip. It provides a steep dropoff from 5 to 20 feet in the northwest and 15- or 20-foot dropoffs further down the harbor edge. Lesser drops range along the eastern edge. The lagoon ranges down to about 8 feet in depth except for a small 10-foot hole opposite the harbormasters hoist. A small beach exists in the northwest corner of the harbor.

Belmont Harbor has a great variety of bottom materials. Generally the areas deeper than 20 feet on the west and 15 feet on the east part of the main harbor are covered with clayey organic silt. The harbor-mouth areas exposed to open lake wave fronts are mainly covered with sand and sandy silt extending into the mouth proper. Except for fixed dock areas southeast of the harbormaster's office, the harbor floor is edged with gravel and gravelly

sand. Sand from the open lake extends westward into the harbor mouth. A small unexplained area of pebbly clay till is exposed east of the Chicago Yacht Club docks. The harbor mouth at Belmont is open and flat without the deep channel found in other Chicago small boat harbors. Despite this openness, which allows significant wave fronts to enter the harbor, a large interior area lies 5 or 6 feet below the broad entrance sill and out of direct line with the mouth. Consequently wave action does not flush the deeper parts of the interior as organic clayey silts are deposited in this area. The high organic content also suggests that at times anaerobic conditions exist.

Aquatic plants occur in the shallows of the lagoon as well as along the dropoff slopes of the western edges. Plants follow those slopes southward from the beach wrapping around the south end up toward the harbor mouth. Some weeds were collected along the edges at the mouth. There, Savitz and others (1990) have identified the spiny naiad, slender naiad, Elodea sp., Myriophyllum verticillatum, flatleaf pond weed, Vasey's pond weed. Nitella sp. was found at depths below 15 feet in small areas.

DIVERSEY HARBOR

Diversey Harbor (Appendix A, Plate 3), located in south Lincoln Park, is a 6200-foot long facility that trends NNW/SSE and consists of an oval main harbor on the north and the narrow long South Lagoon on the south. The Fullerton Parkway bridge divides the harbor nearly in half. Only a narrow neck of land separates the harbor from the open lake. The main harbor extends from the Fullerton bridge 2200 feet north to Diversey Parkway. Maximum width is 660 feet. The narrow elongate south lagoon extends from 240 feet north of the Fullerton bridge south-southeastward for more than 3800 feet. It reaches a maximum width of 230 feet near its midlength and nowhere is less that 80 feet wide. It is generally more than 150 feet wide. The greater harbor area covers 27 acres of which about 14 are in the south lagoon. Both are edged by steel sheet-pile and concrete.

The main harbor is relatively deep. In two areas, one west of the Lake Shore Drive bridge at the harbor mouth and the other near the east side of the northern third of the main harbor, depths exceed 24 feet LWD. The combined areas cover about 2 1/2 acres. These two deeps may be surge or current phenomena kept open by flows resulting from lake level variations, or channels constructed or kept open by dredging, or caused by a combination of these two factors. The main part of the harbor lies more than 17 feet deep LWD and covers approximately 8 acres. Approximately 14 acres lie below the 10-foot LWD level. The sill at the harbor entrance is at a 9-foot depth. Consequently the greatest part of the harbor floor is well below the sill providing conditions under which oxygen supplies at times may be low. Dropoffs descending from the 10-foot level occur on the west side of the harbor. They extend south from the launch ramp at the north, passing beneath the fixed docks to the south end of the main harbor. A lesser drop off occurs on the east side extending from 200 feet south of the harbor mouth for 600 feet southward. Star docks fill the middle of the main harbor. East of Lake Shore Drive, the outer part of the harbor mouth exceeds 13 feet in depth and may be kept scoured by currents caused by lake-level changes and wave action. These currents were noted during the field season to cause eddies and standing

surface waves, and were strong enough to cause difficulty in boat handling. The South Lagoon is shallow. Only two small areas exceed 11 feet LWD. One is near the Fullerton bridge, and the other is some 500 feet farther south. In general, the lagoon is 4 to 6 feet deep, except for the southernmost 800 feet, which generally is only 2 to 3 feet in depth.

Most of the harbor bottom is covered by fine sand and silt which compares with materials from which the harbor originally was built. With the exception of the channel in the harbor entrance, the deeper parts of the main harbor are underlain by silt. A small area at the northwestern end of the fixed docks likewise is silty. Coarser sediments - sand and gravel - are limited to the northeast shallows, the harbor mouth, a small spot in the fixed dock area and the south end of the main harbor where the South Lagoon begins. Lagoon bottom materials are dominated by sand and gravel along the sides in the southern two-thirds. In the northern third, they cover the entire bottom. Fine materials may be flushed out of that area by currents associated with the Fullerton bridge. The central area of the southern third is dominated by organic silt. Gravel, cobbles and boulders are found in several places along the sides. They are found near the bridge on the east side. They likewise are found along the west side of the southern half of the lagoon along with some failed revetment blocks.

Occurrences of undifferentiated aquatic weeds were recorded during sediment sample collections in Diversey Harbor. Most notable was a large area in the northwest corner. There weeds occurred in the shallows above the 10-foot level all along the northern harbor edge and extended west and southward along the western edge as far south as the main fixed-dock complex. Similarly, weeds occurred discontinuously along the eastern edge and patchily in the main fixed-dock area. Weeds were found below 20 feet in two minor patches. In the south lagoon, weeds were rare although suspended algae were abundant in the southernmost parts. Savitz and others (1990) have listed aquatic plants found at Diversey. They recorded patches of Chara sp. along the sides of the harbor. Recorded along the eastern shore of the main harbor as well as the eastern, western and southern portions of the southern most tip of the South Lagoon were spiny naiad, slender naiad, Elodea sp., Myriophyllum verticillatum, flatleaf pondweed and Vasey's pondweed.

59TH STREET HARBOR

Fifty-ninth Street Harbor (Appendix A, Plate 4) is a small pocket harbor located south of the Museum of Science and Industry due east of the end of the Midway Plaisance. It covers about 16 acres and is the isolated northeastern part of a large circular lagoon system, part of which is the Paul H. Douglas Nature Sanctuary. The harbor is elongate NE/SW. It is more than 950 feet long and is 350 feet wide at its maximum. On the west it is bounded by a small dam. The shore edge consists of a steel sheet-pile and concrete seawall. The harbor is small, with a long, narrow, jetty-protected entrance which passes under Lake Shore Drive and projects 800 feet out into Lake Michigan.
The harbor is quite shallow, averaging about 8 feet depth LWD over most of its interior. Maximum depths in excess of 14 feet are found in the channel just landward of the Lake Shore Drive bridge.

Coarse gravel, gravel and sand cover the harbor entranceway and the deepest part of the channel, indicating that harbor-entrance currents prevent deposition of fine-grained material and may help maintain the channel. Sand covers the eastern third of the harbor floor whereas sandy silt occurs in a band across the middle part. The westernmost part of the harbor is floored by clayey organic silt, indicating that significant flushing by lake-level changes and storm surges does not reach the western third.

Aquatic weeds were found patchily in the western part of the harbor. Chara sp. grows on most shore protection structures. Savitz and others (1990) identified spiny naiad, slender naiad, Elodea sp., Myriophyllum verticillatum, flatleaf pondweed, and Vasey's pondweed. Nitella sp. was found in depths greater than 14 feet.

JACKSON PARK HARBORS

Jackson Park Harbors (Appendix A, Plate 5) are the southernmost of the Chicago small boat harbors. Covering 48 acres, the inner and outer harbors are of nearly equal acreage and are connected on the south by a narrow channel beneath the Coast Guard Drive bridge. The entrance is broad and open, protected on the north by a seawall. The outer harbor is edged by steel sheet-pile, and concrete backed by stepped stone blocks near the entrance. The south side is retained by a concrete wall and, in the southeast corner, a small beach fronts the shore. In the inner harbor, the shore is relatively natural. From the vicinity of the Southern Shores Yacht Club, steel sheet-pile and concrete extend southward along the fixed docks to near the south end of the parking lot. The shores along the mouth of the Coast Guard Drive bridge channel are steel sheet-pile and concrete for about 300 feet westward.

The outer harbor depth is variable but ranges up and down only a few feet from the 10-foot LWD level. The entrance to the open lake is controlled by a 6-foot deep sill just outside the mouth which greatly reduces the wave energy that enters the harbor from the outside. There is an elongate depression of 10-foot depth that begins at the mouth and extends almost to the U.S. Coast Guard building on the northwest shore. The depression ends in a 19-foot restricted hole off the Coast Guard dock. Except for that hole and a 20-foot deep, narrow channel extending more than 200 feet eastward from Coast Guard Drive bridge and 400 feet westward, the outer harbor bottom is gently undulating. The inner harbor bottom is flat, ranging from 8 to 9 feet in depth over virtually its entire area. There are very shallow parts along the northeastern shore which drop off to 7 or 8 feet. Generally, however, slopes are gentle from shore to bottom depths.

The northern parts of the outer harbor floor are covered with sand. A sand and gravel bed with some cobbles floors the outer part of the relatively open harbor mouth. Much of the southern half of the harbor is bottomed with sand and sandy silt with a small one acre area of clayey organic silt and clay in the middle. Associated with the Coast Guard Drive bridge is a large area of sandy gravelly bottom, indicating current-induced scour associated with water exchange between the two halves of the harbor caused by changes in lake level. Glacial till is exposed in the deepest parts of the bridge surge channel, due either to current scour or dredging. The gravelly sandy bottom area extends

westward into the inner harbor. From the Coast Guard Drive bridge, the inner harbor floor grades northwestward into sandy silt, thence into heavily organic clayey silt which covers most of the inner harbor bottom.

Savitz and others (1990) report Chara sp. attached to solid structures along the shores. They also identified spiney naiad, slender naiad, Elodea sp., Myriophyllum verticillatum, flatleaf pondweed and Vasey's pondweed among the macrophytes living along the western shoreline and patchily in the southern part of the outer harbor as well as along the northeastern shore. They also noted eel grass growing along the shallows of the inner harbor. Macrophytes also grow extensively along the shallow western slopes of the inner harbor.

MAPS OF THE OPEN LAKESHORE

Introduction

Making basic bottom materials maps of the open shore for fishery management is a developing technology for the Illinois Lake Michigan shore. The 1-1/2 mile by approximately 1 mile map areas presented here were chosen because they represent units that can be completed each in a few months. Consequently, these maps should be considered developing products in their relatively early stages with much refinement remaining. The Lincoln Park and Edgewater map areas were first chosen because they offered considerable variety in shore structures as well as bottom conditions. The Lincoln Park map contains a small boat harbor and a much used fishing groin as well as interesting bottom configurations derived from wave returns, wave reflections and refractions. Edgewater covers new offshore breakwaters and represents significant parts of privately owned shoreland.

Lincoln Park, Chicago

Lakefront Characteristics- The Lincoln Park map (Appendix B, Plate 6) covers 1-1/2 miles of shore reaching northward from West Gordon Terrace on the south to just north of Foster Avenue. In east-west dimension, the map covers a little more than a mile.

The Lincoln Park shore in the southern map area is fronted mainly by stepped stone block revetments. The reach from the Montrose Harbor mouth southward is protected by a revetment consisting of a double wall of wooden piling covered by wooden sheeting. The area between pile walls is filled with rock rubble which is capped by stone blocks. The front wall is protected by a toe apron of large dolomite riprap blocks. Referred to as the D-1 type of revetment by the Chicago Park District, a diagram of the structure is shown in Figure 2.

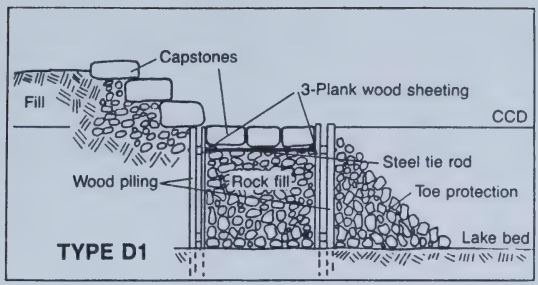

Figure 2. Diagram of a Chicago Park District Type D1 shore protection revetment (from Chrzastowski and Schlee, 1988, from Chicago Park District, 1944, 1947, 1987)

Extending eastward and northward from the Montrose Harbor mouth to the Wilson Avenue Groin, a Chicago Park District Type C stepped stone revetment protects the shore. Shown below, this type of structure consists of two rows of wooden pilings (without wood sheeting) which retain rock fill between the rows of piles. The fill supports four tiers of stepped stone blocks. The toe of the structure is protected by a broad apron of large riprap stone blocks between which large open voids exist. Where maintained, the C structure protects the fill by reducing wave splash and dispersing wave impacts.

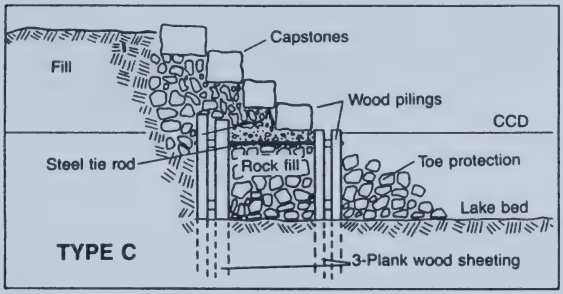

Figure 3. Diagram of a Chicago Park District Type C shore protection revetment (from Chrzastowski and Schlee, 1988, from Chicago Park District, 1944, 1947, 1987)

As a consequence of low maintenance, however, these structures, particularly along the shore south, southeast and east of Montrose Harbor, have experienced pile shrinkage (Chrzastowski and Schlee, 1988) as well as a number of failures in the outer piling wall. Capstones and the rock fill have slumped and moved lakeward. Where such failures have occurred, open spaces within the structures have increased. The diagram below shows details of a failed piling wall.

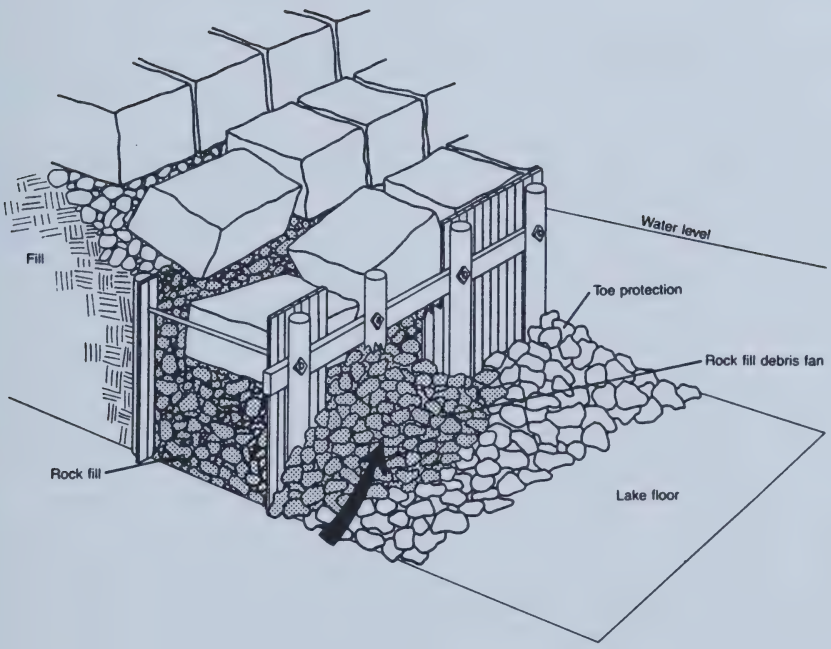

Figure 4. Diagram of a failed Chicago Park District Type C shore protection revetment (from Chrzastowski and Schlee, 1988, from Chicago Park District, 1944, 1947, 1987)

Wilson Avenue Groin is made of steel sheet piling capped by a concrete deck. Its entire eastern side is well protected by a riprap toe apron. There is toe protection at the spiral coil of the distal end to where two deep holes (26 and 30 feet, respectively) are recorded. The groin is one of the favorite fishing locations in the area.

Westward from Wilson Avenue Groin, Montrose-Wilson Beach extends for 3000 feet. It is an emergent portion of the littoral sand apron that extends from one to three thousand feet into the lake.

From Montrose-Wilson Beach northward to Foster Avenue Groin, the shore is protected by revetments much like those near Montrose Harbor but with steel sheet-pilings instead of wooden pilings as in the C structures. The steel sheet-pile structures are referred to as type C-1 revetments by the Chicago Park District. There have been no significant failures even though little or no toe protection is used. Because of the lack of toe protection, however, the lakebed adjacent to the structure suffers considerable scour. Commonly there is a deep trough next to the shore.

Another structure that affects the distribution of bottom materials is the groin at Foster Avenue. It is steel-sided and concrete-capped with little or no toe protection.

Bathymetry - The characteristics of lake floor materials are clearly reflected in the bathymetry which reveals two distinct depth regimes. The first, adjacent to the shore, represents the littoral sand apron extending 2500 feet offshore at Foster Avenue Groin, 1800 feet along the west side of Wilson Avenue Groin and 2400 feet off the mouth of Montrose Harbor, all part of a smooth gradual slope down to approximately the 20-foot LWD depth. The general rate of descent is one foot in about every 160 feet (1:160) lakeward. Where storm waves from the northeast pile waters onto landward side of Wilson Avenue Groin, the slope ranges from 1:70 to 1:17 at the end of the groin. Storm currents rushing around the western side of the groin have scoured a channel as well as two holes 5 to 8 feet deep, reaching a maximum depth of 30 feet at the spiral end of the groin. Water is deep along the east side of Wilson Avenue Groin. Currents wrapping around the end and wave reflections focused by the concave configuration have caused a narrow shallow trough near mid-length of the groin. Depths of 15 to 20 feet occur along the lakeward side and continue to the southeast side of Montrose Peninsula. East and southeast of the harbor mouth the slope is only 1:23 to 1:35. The second depth regime is beyond the 20-foot depth line extending to the eastern edge of the map. The general slope over the area is only 1:1000 but is made up of subdued hummocks and swales. The hummocks are ovoid, oriented north-south. They are between 150 and 1000 feet long, 25-200 feet wide and 2 to 4 feet higher than the surrounding lake floor. Swales generally have the same dimensions but are only 1-3 feet deep, somewhat more subdued than the hummocks.

Distribution of Bottom Materials - Surficial materials that floor the open lake in the Lincoln Park area consist of 1) silt, sand, gravel and cobbles of the nearshore areas, 2) glacigenic pebbly clay (till) that underlies the entire area but is exposed in the nearshore by dredging and/or scour, 3) glacigenic pebbly clay (till) generally exposed offshore on the open lake floor, 4) current and wave distributed silts, sands and gravels that form a

discontinuous and irregular mobile veneer on the offshore till, 5) sands, gravels and boulders derived from the till resting on the surface as well as embedded in original position as part of the till, partially exhumed by wave and current scour, 6) gravels, cobbles, boulders and blocks of bedrock scattered by prehistoric glacial action making up part of the sediment veneer on the till.

The distribution of bottom materials can be differentiated into five distinct compositional areas.

1. The area next to the shore, northwest of Wilson Avenue Groin, is covered by a lakeward-thinning wedge-shaped littoral sand apron. The apron fronts the Illinois shore in most places. Thickness ranges up to 13 to 15 feet adjacent to the shore tapering to a zero edge 1200 to 3200 feet offshore (Shabica and others, 1991) where it meets the till bottom. The littoral apron contains some coarser sand and gravel in the beaches and close to the shore. Mainly it consists of fine sand, that gently slopes lakeward in a relatively featureless bottom. Nearshore sand bars are built and destroyed as wave and water level conditions change.

2. The northeast quadrant of the open lake area is floored by an irregular gray pebbly clay till. The surface's irregularity may be partly attributed to an original hummocky depositional character, partly to erosion during post-glacial exposure, and partly to recent wave and current action. An irregular veneer of silt, sand, gravel, cobbles and boulders lies on the till surface. It may be several feet thick. The materials have been derived from several sources:

   a) Sand, gravel, cobbles and boulders, which are constituents of the clay till, have been left behind following subaerial and subaqueous erosion which removed the clay along with finer sand and silt.

   b) Bodies of mobilized silt and sand, derived from the littoral sand apron, have been moved offshore as sheets and dunes by deep waves and currents.

   c) Materials left behind during glacial melting are scattered over the lake floor. Some were deposited by proglacial rivers, lakes and streams.

   The elongate hummocks and swales shown by this map are characteristic of the above materials. Distribution is irregular and everchanging. It is on this surface that boulder beds and cobble pavements are found.

3. Eastward from Wilson Avenue Groin and Montrose Peninsula, sand and silt bodies alternate with clay till bottom with characteristics as described above. Relatively thick sands are retained northwest of Wilson Avenue Groin. Waves piling onto the Montrose-Wilson Beach establish north-flowing currents along the west side of the groin and wash sandy materials around the spiral tip. These materials are then thinly spread over this area, much of the material being washed farther offshore. Silt has mixed with the clay on the east side of the groin. Focused wave fronts and current action derived from wave impacts greatly affect sediment distribution. Fine sand and silt have accumulated in the

relatively protected reentrant of the Montrose Harbor mouth. Riprap provides toe protection for the east side of Montrose Peninsula and the outer side of Wilson Avenue Groin.

In the nearshore, just east of the Montrose Peninsula, there is a low mound which is almost 400 feet in greatest length but only 5 feet high. Chrzastowski (1989) has identified it as the former site of a water intake crib. There are two additional mounds south of the Montrose Harbor mouth in 11-12 feet of water whose morphology suggests dumped debris.

4. Bottom materials of Montrose Harbor are discussed in a separate section. They consist mainly of fine sand and organic clayey silt except in the vicinity of the harbor mouth where coarse sand and gravel and exposed till.

Edgewater District, Chicago

The map area covered here (Appendix B, plate 7) extends 1-1/2 miles along the Chicago shore from south of Foster Drive northward to Devon Avenue (West Sheridan Road at the lake). The area width is just over a mile. From the shore eastward, the map covers up to 4800 feet of lake.

Lakefront characteristics- The southern half of the map area is in park land, part of Lincoln Park under the jurisdiction of the Chicago Park District. From Ardmore Avenue northward the shore includes two additional small city parks: George A. Lane Beach and Park and Albert E. Berger Beach and Park, covering 250 feet and 500 feet of shore respectively. With the exception of street ends, the remainder of the shore (nearly half of the reach covered by the map) consists of private property protected by a variety of shore protection structures.

The shore revetment extending from Foster Avenue Groin northward to Hollywood Avenue Groin consists of parallel steel sheet-pile walls filled with rubble and capped by a concrete walk. The walk is backed by tiers of stepped stone blocks. This type of structure, termed the B-1 Type by the Chicago Park District, generally has no toe protection on the adjacent bottom. Consequently, wave energy is diverted both upward and downward, scouring a trough adjacent to the wall. Furthermore, a wall such as this is very reflective of wave fronts and causes concentrations of wave energy along the shore depending on wave frequency and direction. The lake bottom in front of B-1 structures tends to be relatively featureless except for sand waves. Along this part of Lincoln Park there are two steel sheet-pile, concrete-capped groins at Foster Avenue and Hollywood Avenue. Both are highly reflective of wave fronts and have scoured deep holes at their distal ends, 13 and 14 feet deep respectively. These holes may be significant for fishermen. There are two beaches in this part of Lincoln Park. Foster Avenue Beach, between Foster and Berwyn, is a pocket beach recessed into the shore. It provides protection for that part of the shore. Hollywood Avenue Beach, retained by the Hollywood Avenue Groin, generally extends from Hollywood halfway to Thorndale Avenue. It fronts some 1500 feet of shore and represents the shoreward part of the littoral sand apron that extends alongshore throughout the map area. The beach extends some 500 feet from shore, half of

it under water. Private condominiums mainly occupy the shore north of Hollywood Beach. As far as George A. Lane Park, new riprap revetments protect them well and provide open interstitial space for fry as well as larger fish during quiet water periods. George A. Lane Beach is a pocket beach. It is of special importance because a 140-foot long offshore breakwater of riprap was recently installed 75 to 100 feet off the beach. At times the offshore breakwater is connected to the shore by exposed sand.

The 250 feet north of Thorndale Avenue is occupied by Temple Emannuel. The shore is reveted with riprap. Northward to Glenlake Avenue, however, vertical steel sheet-piling fronts the shore. It is associated with high wave impact, oversplash and bottom scour. Between Glenlake and Granville about half of the shore is protected by riprap revetments and half by vertical steel sheet-piling. Between Granville Avenue and Rosemont the shore is well protected by riprap revetment at Berger Park as well as at the condominium just south of Rosemont. The south half of the shore reach between Rosemont and Devon (Sheridan Road) represents riprap-protected condominiums. The shore belonging to Mundelein College, however, consists of vertical steel sheet-piling which generates great wave oversplash and scour.

Bathymetry - The gradual increase in water depths lakeward to about 21 feet LWD, where smooth isobaths change to irregular ones, marks the edge of the gently sloping littoral sand apron where the littoral sand becomes very thin to absent. Along one reach, between Hollywood Avenue and Berwyn Avenue, the slope extends to 18-foot depths. Farther south, off Foster Avenue Groin, the break in slope returns to 21-foot depth.

The undulating bottom beyond the sand slopes very gently, measuring between 1:60 and 1:130. The undulations, consisting of hummocks and swales, rise as much as 4 feet above the level bottom and sink to 3 feet below. Oriented west of north, the features range up to 1000 feet long and 200 feet wide. Many are much smaller.

There are two large beaches in the Edgewater area. They and their retaining groins have important effects on the lake bottom hydrography. The larger, the Hollywood Avenue Groin, has caused the building of an elongate flat area at the 5-foot level along the shore south of the groin. Near the south end of that flat is a shallow scour caused by waves piling against the concave revetment face. Waters piled onto the Hollywood Beach race around the tip of the groin causing a 14-foot deep scour hole. The submerged part of the beach shows several nearshore bars caused by the dragging of waves onto the beach slope. The slope is a relatively steep 1:5 or 1:6.

Foster Avenue Beach is a pocket beach recessed in the shore. Its submerged portion slopes steeply at 1:9. There is a 13-foot scour hole at the tip of Foster Avenue Groin as well as submerged sandbars both north and south.

North of George A. Lane Beach, in the area of private condominiums, the nearshore slope ranges between 1:12 and 1:30.

Distribution of Bottom Materials- Distribution of materials on the lake floor in the Edgewater District falls into six main areas:

1) The littoral sand apron north of Hollywood Avenue Groin represents an eastward thinning wedge of fine sand that thins to a variable edge, 2300 to 3700 feet offshore. The sand is fine grained over most of the area but includes some medium to coarse sand very close to the shore, especially near beaches and groins. The edge of the apron appears to be mobile in that it spreads and contracts lakeward-landward up to several hundred feet depending on storm and current conditions. Pods of sand are commonly separated from the sand apron and moved out onto the offshore clay till bottom as thin sheets or dunes.

2) Near the lakeward edge of the littoral sand, some 3100 feet off the foot of Glenlake Avenue, is a large gravelly area lying on the glacial till bottom. The gravel covers almost 40 acres and extends from north of Ardmore Avenue at the south to Granville Avenue at the north. This gravel may be a thicker or more extensive veneer on exposed till or a relict deposit formed during postglacial exposure of the lake bed.

3) Close to and southward from Hollywood Avenue Beach and Groin, the littoral sand apron is quite variable in width and thickness. Maximum thickness of about 10 feet occurs next to the shore where patches of medium to coarse sand and gravel occur. The remainder of the littoral apron consists mainly of fine sand grading finer lakeward.

   Diversion of wave fronts and currents developed by waves piling onto Hollywood Beach carry littoral sediments offshore, spreading portions of the sand body lakeward and developing an irregular pattern of sand interspaced with relatively bare clay till bottom. The surface of the littoral sand slopes so gently that it appears flat and, except for nearshore bars and troughs, is relatively featureless.

4) Offshore, glacial pebbly clay till bottom covers much of the map, and commonly is blanketed by a veneer of silt, sand, gravel, cobbles and boulders which are eroded or exhumed from the clay by wave and current action. They may be widely spread or accumulated into ridges, piles or low dunes that form the longshore elongate hummocks and swales that characterize the offshore bottom.

   Also contributing to the veneer materials scattered over the clay bottom, are relict sediments left behind by the glacier that last occupied the lake. Such materials commonly are coarse and make up gravel and cobble pavements as well as boulder fields.

WORK IN PROGRESS

Two additional maps are included in this report as work in progress: Southwestern Lake Michigan (Appendix C, Plate 8), and Nearshore Areas: Illinois Beach State Park (Appendix D, Plate 9). These maps are in their early stages of development and are intended for in-house use.

SOUTWESTHERN LAKE MICHIGAN

This map (Appendix C, Plate 8), at 1:120,000 scale, essentially represents Figure 1 of Collinson, Norby and Hansel (1979) updated to match the National Ocean Service Chart No. 14905 of 1988 and Chart No. 14904 of 1990. The base map has been developed for the purpose of checking locations of reefs already charted, adding new locations as they are discovered during field work and as geophysical records are interpreted.

Shore culture is derived from U.S. Geological Survey Quadrangle Maps, Illinois Department of Transportation aerial photos, ISGS aerial photos and land surveys, some of which were made for an ISGS/USGS co-op project as well as for the present project. The grid prepared for this project is based on Illinois State Plane Coordinates.

Water depths are taken from National Oceanic and Atmospheric Administration (NOAA) Nautical Charts Nos. 14904 and 14905, Port Washington to Waukegan and Waukegan to South Haven, respectively. They were used to contour isobaths onto the base. A small nearshore portion then was adjusted to 1991 bathymetry prepared by Paul Terpstra as part of USGS Agreement 14-08-0001-A0563 which was viewed and used to make minor adjustments to the 10-foot and 20-foot isobaths in the immediate vicinity of the Illinois-Wisconsin state line. The isobaths, based on the NOAA charts which are polyconic projections, were then adjusted to the Illinois State Plane Coordinate base.

NEARSHORE AREAS: ILLINOIS BEACH STATE PARK

This 1:24,000 scale map (Appendix D, Plate 9) is a compilation of lake bottom features currently mapped with new information to be added as acquired. The longitude/latitude grid lines are based on Illinois State Plane Coordinates. The generalized bathymetry was taken from NOAA Nautical Charts Nos. 14904 and 14905, Port Washington to Waukegan and Waukegan to South Haven, respectively.

A small nearshore portion was adjusted to 1991 bathymetry prepared by Paul Terpstra as part of USGS Agreement 14-08-0001-A0563 which was viewed and used to make minor adjustments to the 10-foot and 20-foot isobaths in the immediate vicinity of the Illinois-Wisconsin state line.

ACKNOWLEDGEMENTS

Shore culture for project maps is revised from maps originally prepared by Paul D. Terpstra from U.S. Geological Survey 7-minute Quadrangle maps and revised by him, James R. Jennings and Christine S. Fucciolo. Their efforts brought the maps up-to-date and improved their accuracy. These efforts were supported in part by the Illinois State Geological Survey, and by the U.S. Geological Survey Southern Lake Michigan Coastal Erosion Program, Agreement 14-08-0001-A0563, and by the Illinois State Department of Conservation Project No. F-112-R-1.

Bathymetry of the small boat harbor maps, like the shore culture, was prepared through efforts and aforementioned contracts from the three agencies, ISGS, USGS and IDOC. A number of persons contributed to early versions: Michael J. Chrzastowski, Matthew H. Riggs, Terrie P. Adams, Sharon L. Horstman, as well as others under ISGS/USGS support. Much new bathymetry was run under IDOC Project No. F-112-R-1 and ISGS support. Bottom materials maps were exclusively funded by IDOC contract F-112-R-1.

Special map digitizing was done by Sandra Cole. Word processing was done by Rebecca J. Roeper and Gail M. Gray. Elwood Atherton and Rodney D. Norby critically reviewed this report. We greatly appreciate their help.

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INTRODUCTION TO THE MAP APPENDICES

The maps displayed in the appendices represent draft materials stored in a mainframe computer from which they may be retrieved at virtually any practical scale. Most represent the best information available at present but will be updated whenever additional information becomes available as the present project continues.

The Montrose, Belmont and Diversey Harbor maps have been corrected to fit precise land surveys. The remaining maps have been based on USGS Quadrangle sheets and Illinois Department of Transportation high altitude aerial photographs. All maps eventually will be adjusted to new detailed land surveys.

All maps are in a developmental mode and will be modified significantly during coming months. Whenever a copy is requested, it will be the most up-to-date version available.

In their computerized form, all of the constituent parts of the present maps can be partitioned, combined or otherwise adjusted to fit special research purposes.

Included in the Appendices are:

Appendix A

Shore Features, Water Depths, and Bottom Materials Distribution:

Plate 1. Montrose Harbor, Chicago, Illinois
Plate 2. Belmont Harbor, Chicago, Illinois
Plate 3. Diversey Harbor, Chicago, Illinois
Plate 4. 59th St. Harbor, Chicago, Illinois
Plate 5. Jackson Park Harbor, Chicago, Illinois

Bathymetric Profile Lines and Bottom Sample Locations:

Figure 5. Montrose Harbor, Chicago, Illinois
Figure 6. Belmont Harbor, Chicago, Illinois
Figure 7. Diversey Harbor, Chicago, Illinois
Figure 8. 59th St. Harbor, Chicago, Illinois
Figure 9. Jackson Park Harbor, Chicago, Illinois
Figure 10. Lincoln Park, Chicago, Illinois
Figure 11. Edgewater District, Chicago, Illinois

Appendix B

Shore Features, Water Depths, and Bottom Materials Distribution:

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Plate 7: Edgewater District, Chicago, Illinois

Appendix C

Plate 8: Southwestern Lake Michigan:
Map Showing Longitude/Latitude Grid, Bathymetry
and Bedrock Reefs

Appendix D

Plate 9: Nearshore Areas: Illinois Beach State Park:
with Longitude/Latitude Water Depths and
Outlines of Some Bottom Materials Distribution

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING
Illinois Department of Conservation
Dingell-Johnson/Wallup-Breaux
Research Program

ANNUAL REPORT
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Illinois Department of Conservation Project No. F-112-R

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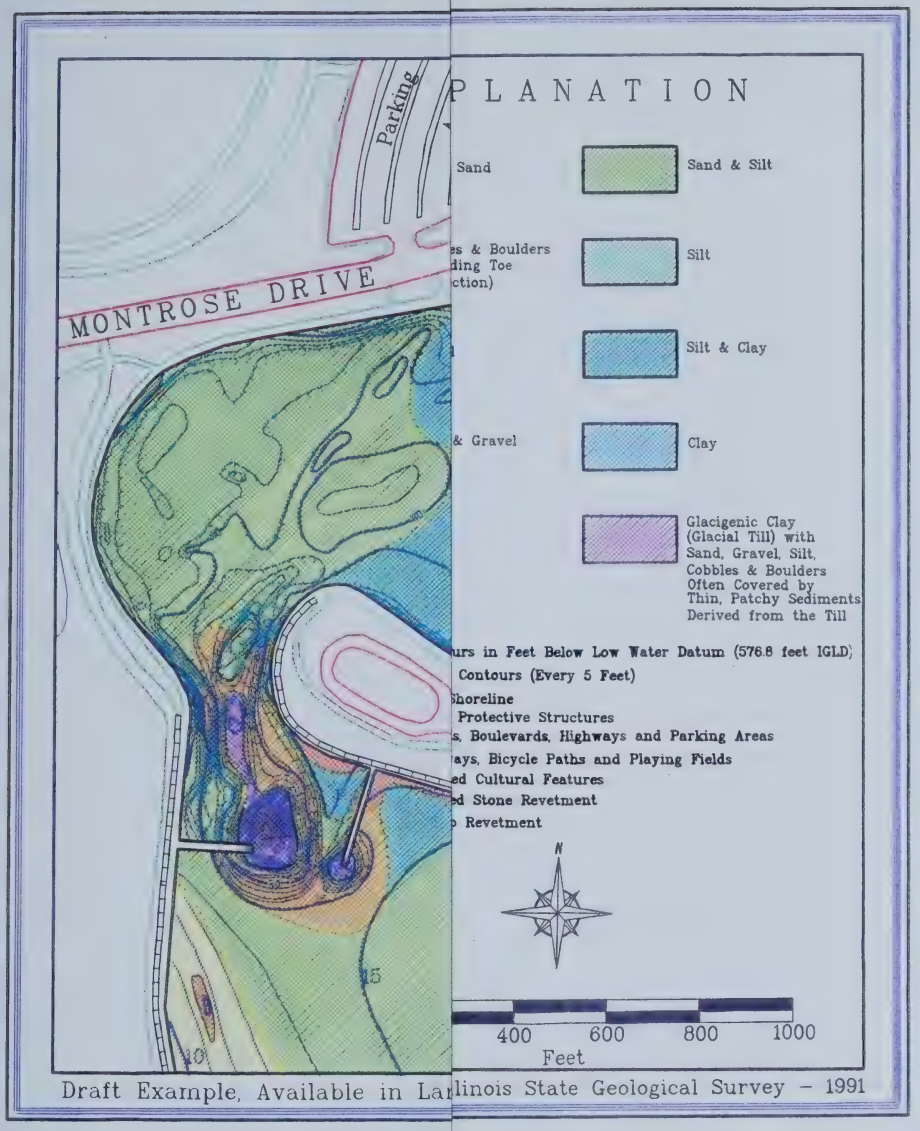
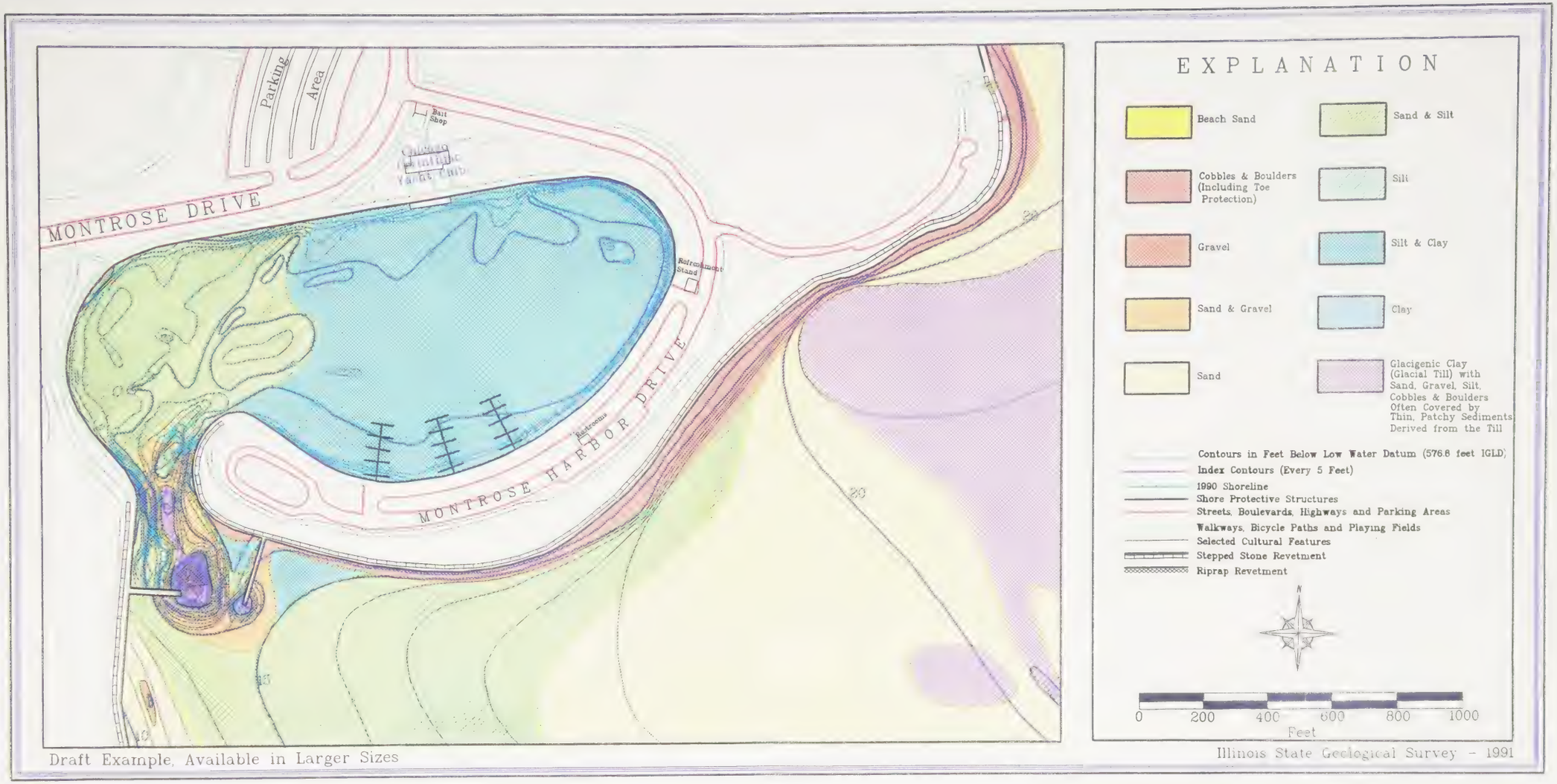
- Figure 11. Edgewater District, Chicago, Illinois

Illinois State Geological Survey
Champaign, IL 61820
August 1991



MONT NOIS

SHORE FEATU ISTRIBUTION



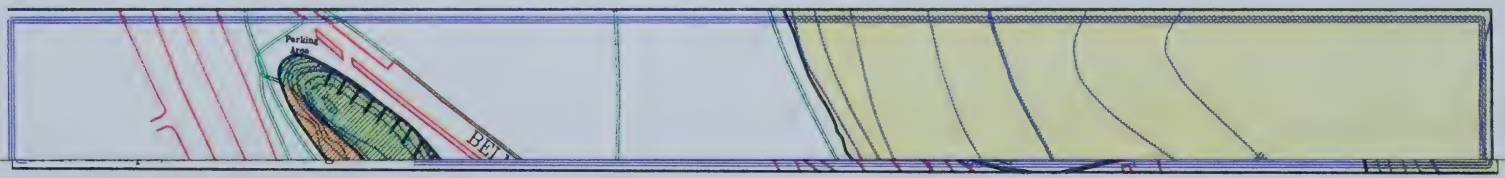
Draft Example, Available in Larger Sizes

Illinois State Geological Survey - 1991

MONTROSE HARBOR - CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

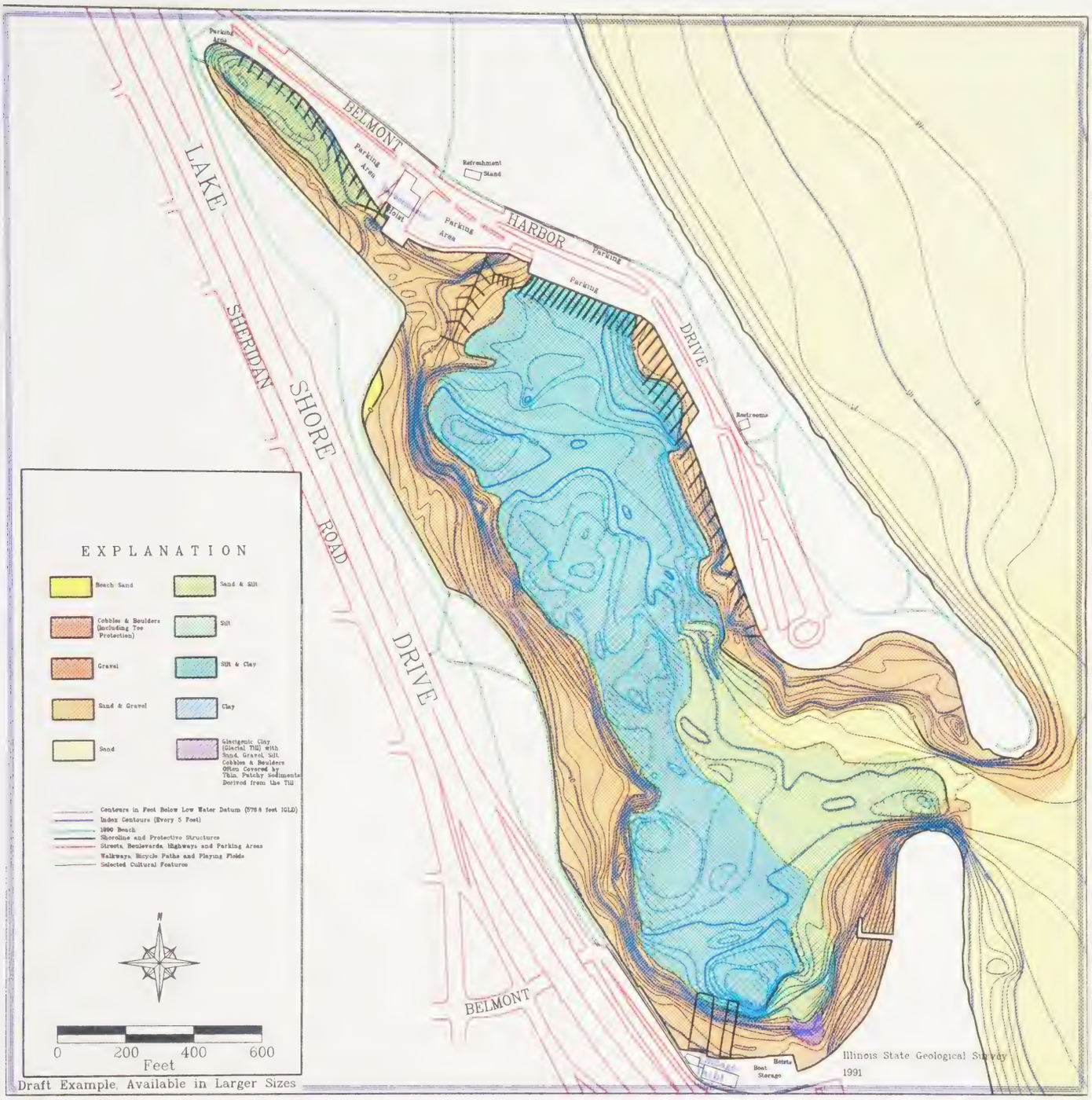
PLATE 2



BELMONT HARBOR – CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

PLATE 2



BELMONT HARBOR – CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

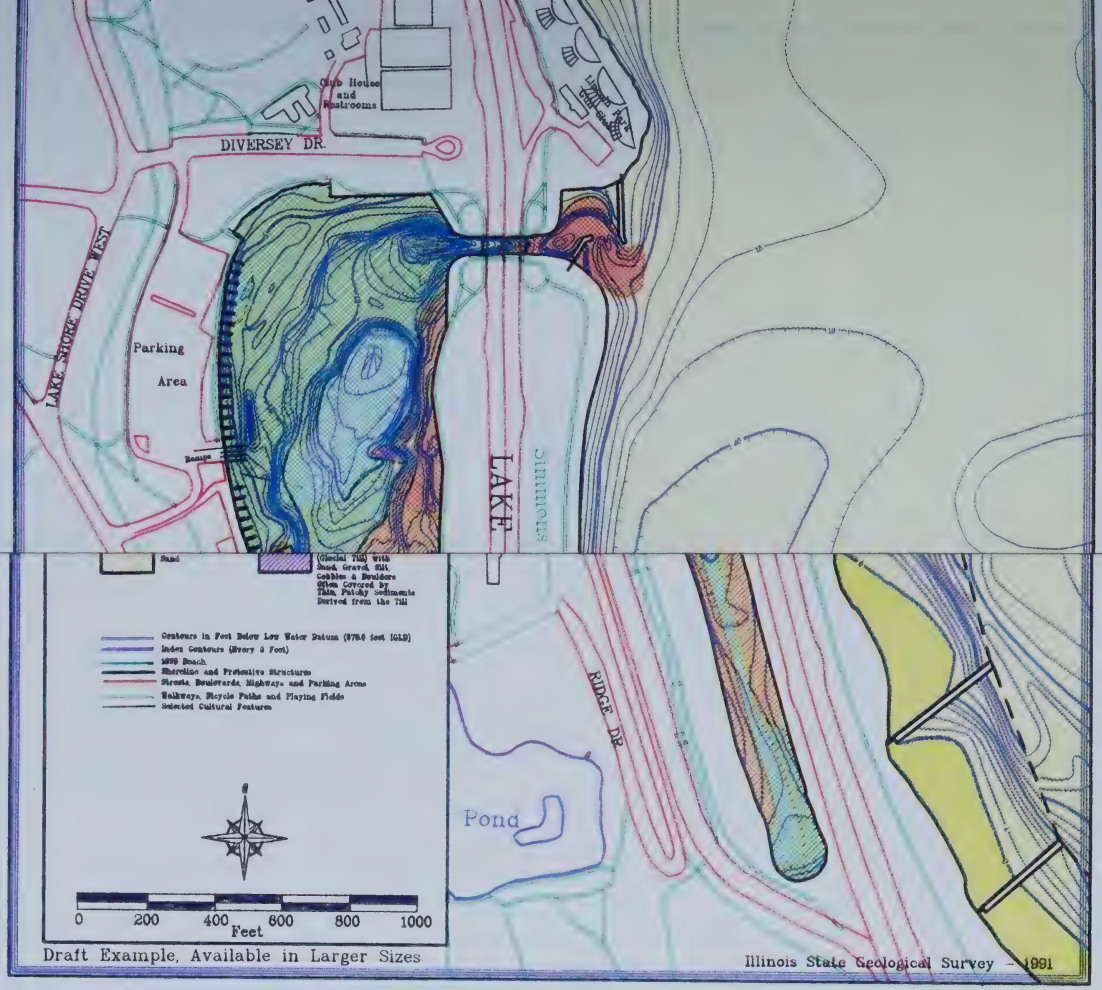

Club House and Restrooms
DIVERSEY DR.
LAKE SHORE DRIVE WEST
Parking Area
LAKE
Simmons
RIDGE DR
Pond
Sand
(Glacial Till With Sand, Gravel, Silt, Cobbles & Boulders Often Covered by Thin, Patchy Sediments Derived from the Till
Contours in Feet Below Low Water Datum (576.6 feet IGLD)
Index Contours (Every 5 Feet)
1990 Beach
Shoreline and Protective Structures
Streets, Boulevards, Highways and Parking Areas
Walkways, Bicycle Paths and Playing Fields
Selected Cultural Features
0 200 400 600 800 1000
Feet
Draft Example, Available in Larger Sizes
Illinois State Geological Survey – 1991

PLATE 3

DIVERSEY HARBOR – CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

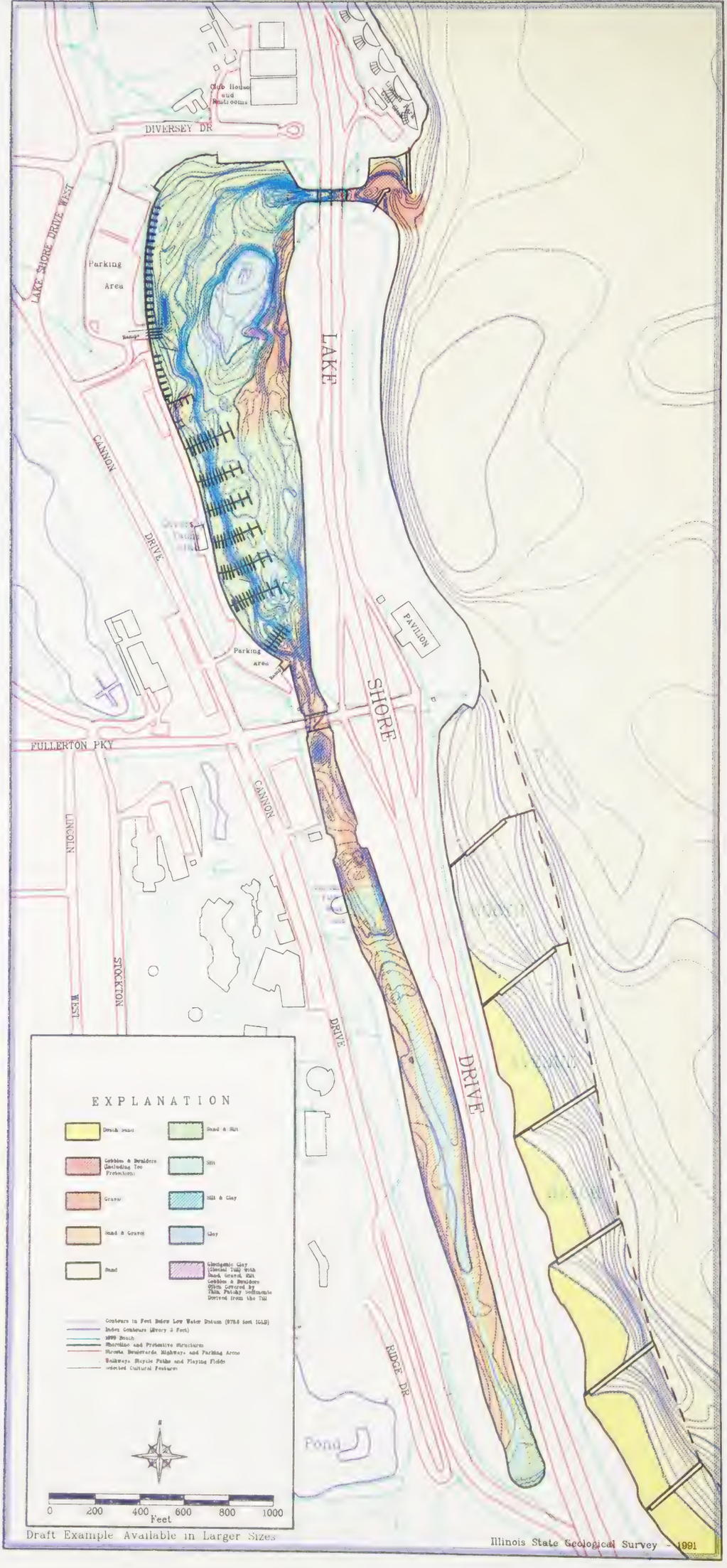
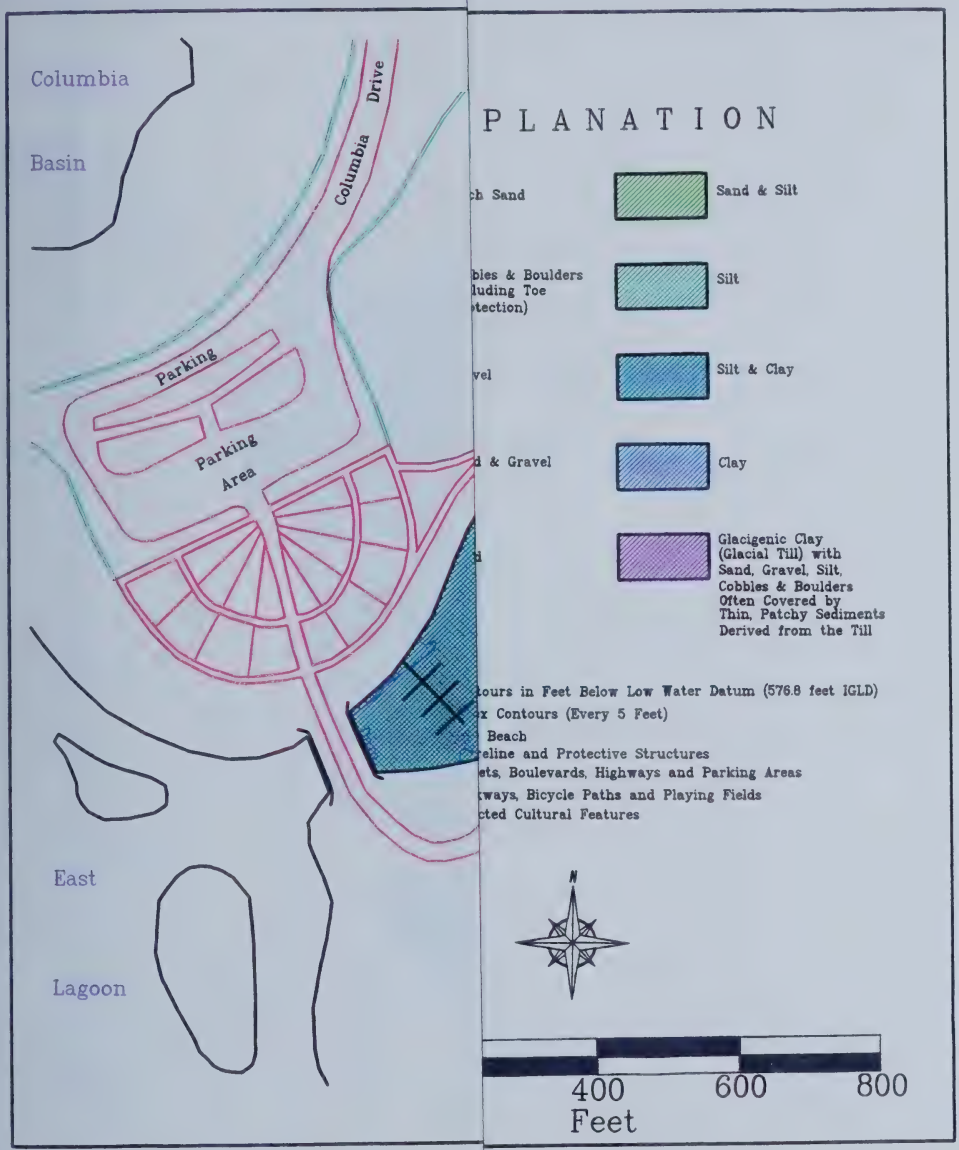


PLATE 3

DIVERSEY HARBOR – CHICAGO, ILLINOIS

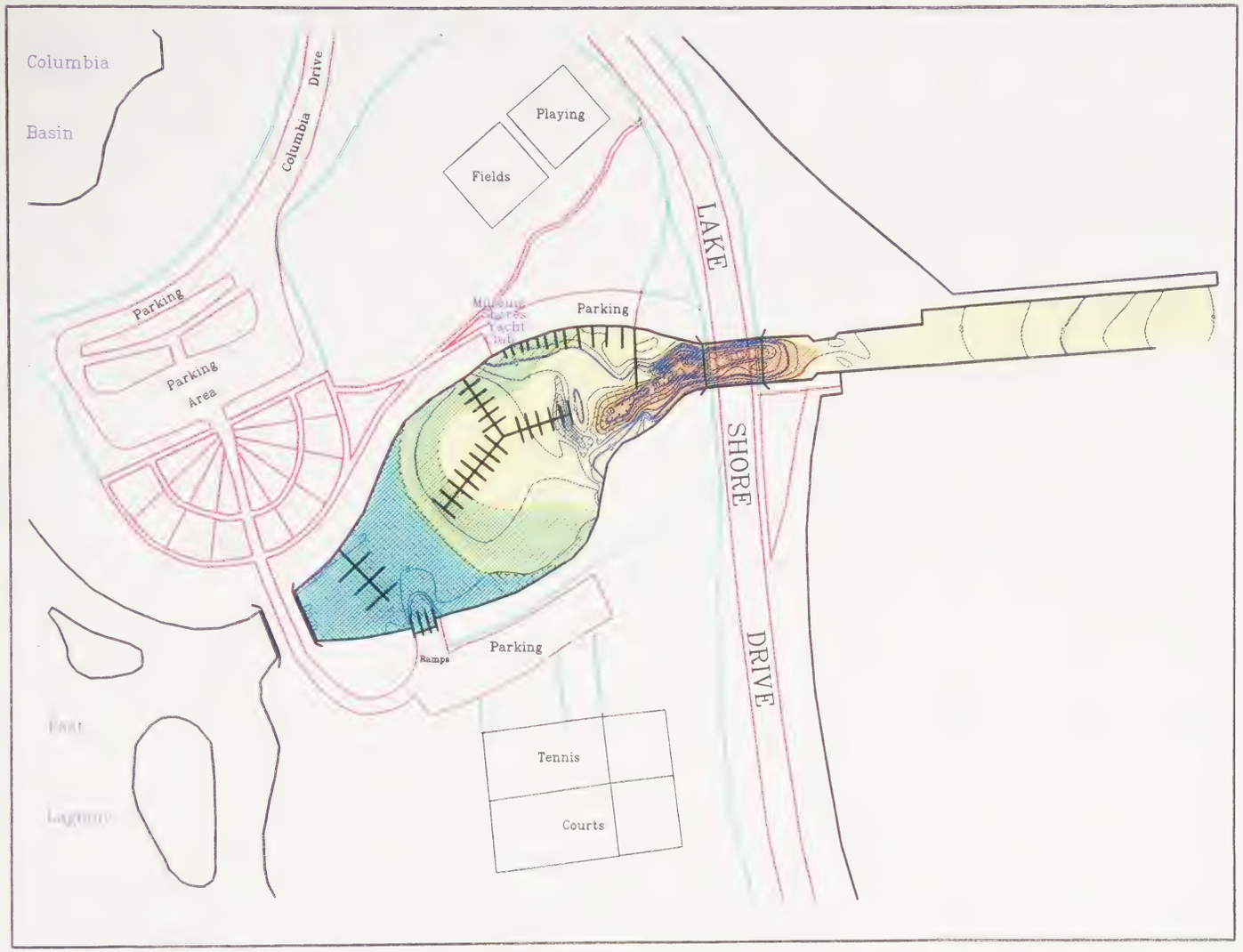
SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION



Draft Example, Available in Larger e Geological Survey – 1991

59th STLLINOIS

SHORE FEATUISTRIBUTION



Draft Example, Available in Larger Sizes

EXPLANATION

- Beach Sand
- Sand & Silt
- Cobbles & Boulders (Including Toe Protection)
- Silt
- Gravel
- Silt & Clay
- Sand & Gravel
- Clay
- Sand
- Glacigenic Clay (Glacial Till) with Sand, Gravel, Silt, Cobbles & Boulders Often Covered by Thin, Patchy Sediments Derived from the Till

- Contours in Feet Below Low Water Datum (576.8 feet IGLD)
- Index Contours (Every 5 Feet)
- 1990 Beach
- Shoreline and Protective Structures
- Streets, Boulevards, Highways and Parking Areas
- Walkways, Bicycle Paths and Playing Fields
- Selected Cultural Features

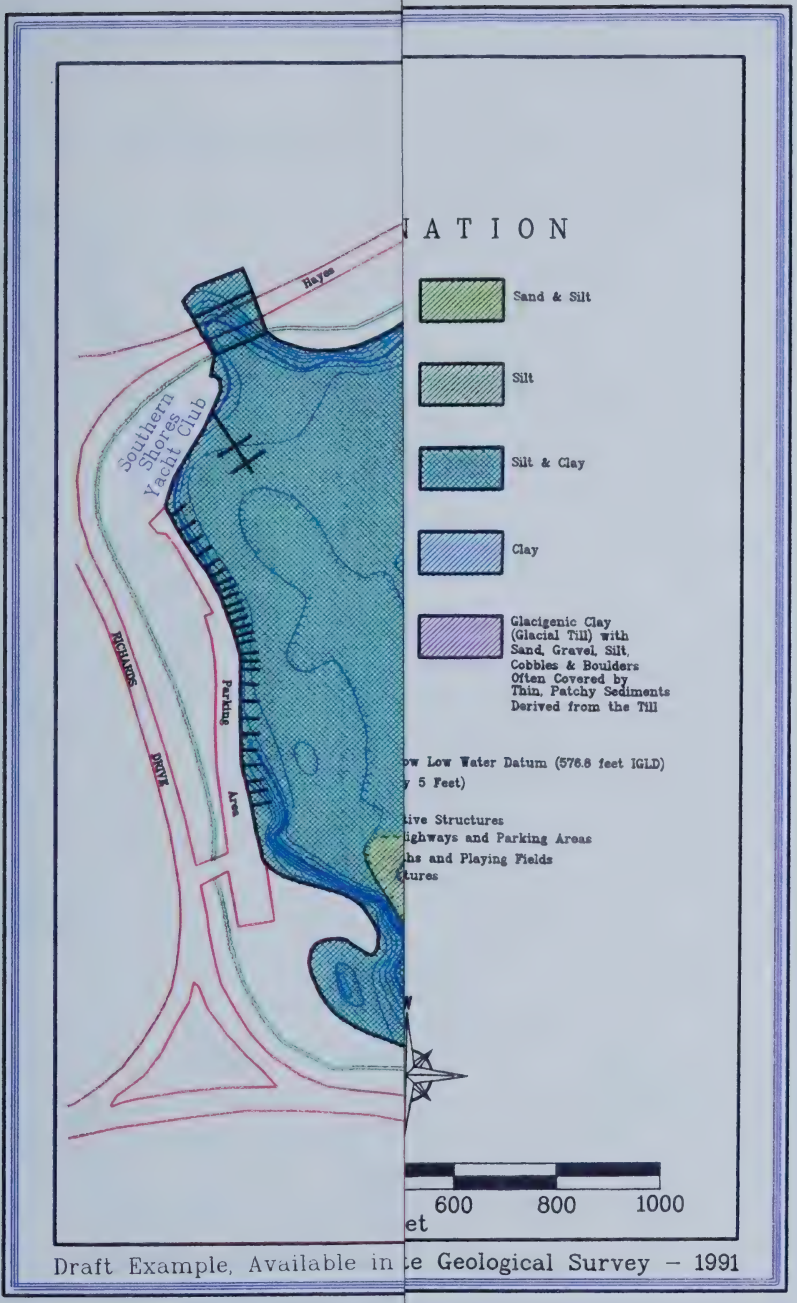
N

0 200 400 600 800
Feet

Illinois State Geological Survey – 1991

59th STREET HARBOR – CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION



Draft Example, Available in te Geological Survey – 1991

JACKOIS

SHORE FEATURES DISTRIBUTION

EXPLANATION

- Beach Sand
- Sand & Silt
- Cobbles & Boulders (Including Toe Protection)
- Silt
- Gravel
- Silt & Clay
- Sand & Gravel
- Clay
- Sand
- Glacigenic Clay (Glacial Till) with Sand, Gravel, Silt, Cobbles & Boulders Often Covered by Thin, Patchy Sediments Derived from the Till

- Contours in Feet Below Low Water Datum (576.8 feet IGLD)
- Index Contours (Every 5 Feet)
- 1990 Beach
- Shoreline and Protective Structures
- Streets, Boulevards, Highways and Parking Areas
- Walkways, Bicycle Paths and Playing Fields
- Selected Cultural Features

N

0 200 400 600 800 1000
Feet

Draft Example, Available in Larger Sizes

Illinois State Geological Survey – 1991

JACKSON PARK HARBOR CHICAGO, ILLINOIS

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

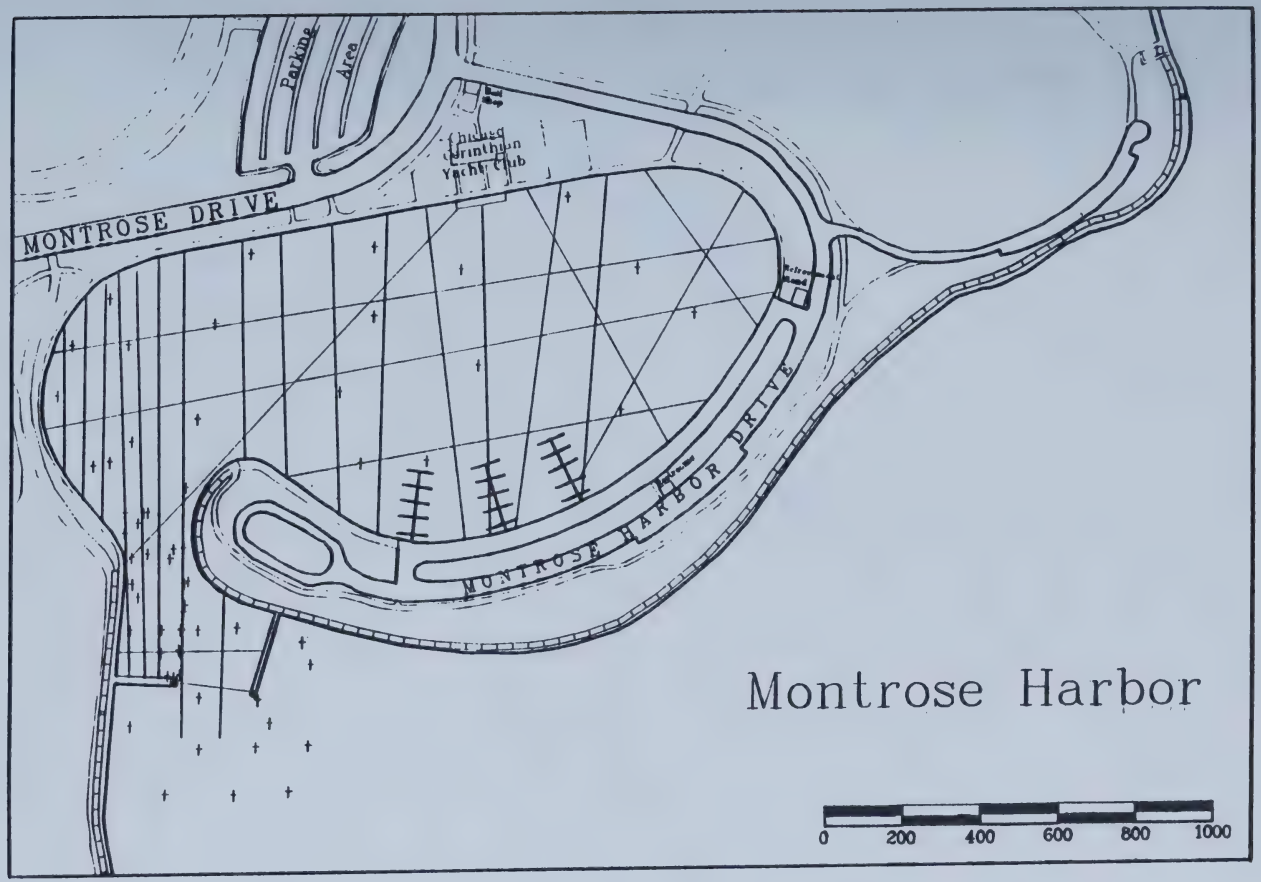


Figure 5. Bathymetric Profile Lines and Bottom Sample Locations: Montrose Harbor, Chicago, Illinois

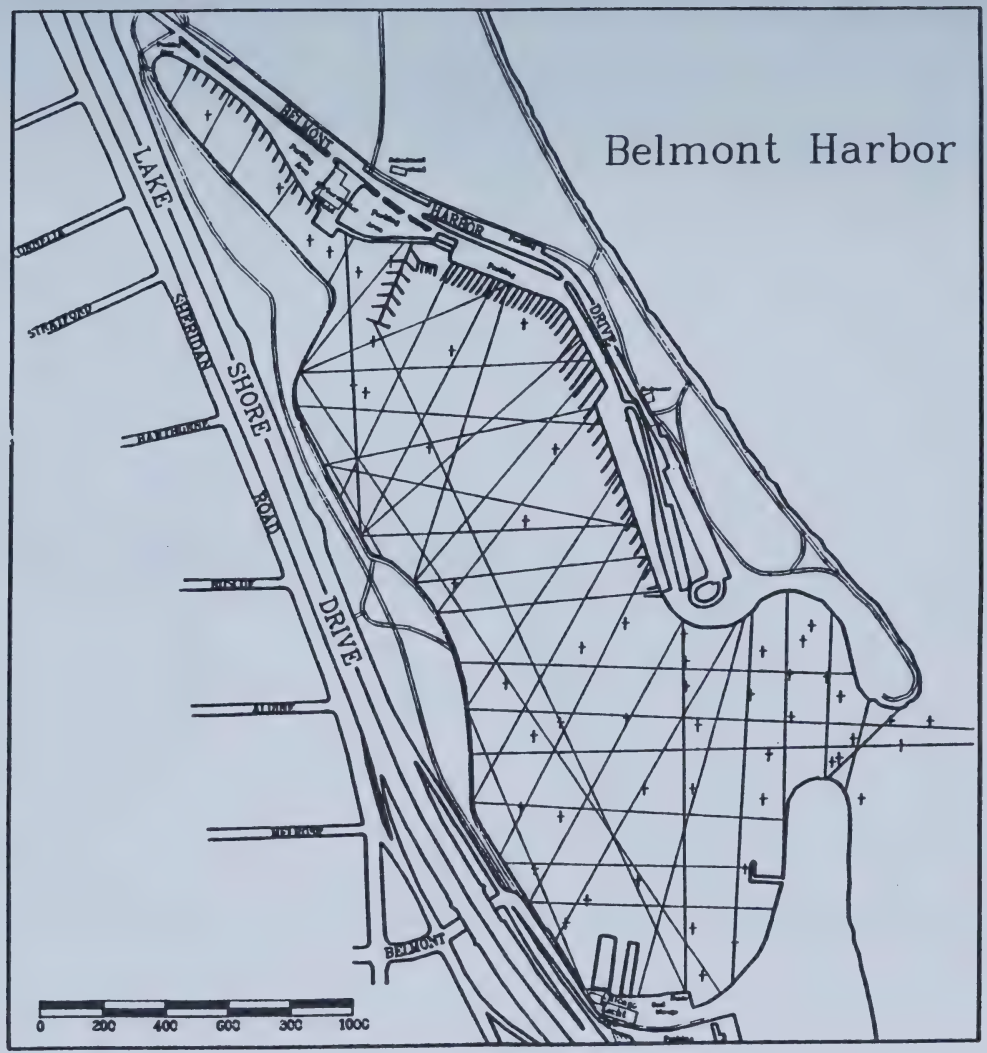


Figure 6. Bathymetric Profile Lines and Bottom Sample Locations:
Belmont Harbor, Chicago, Illinois

Figure 7. Bathymetric Profile
Diversey Harbor,

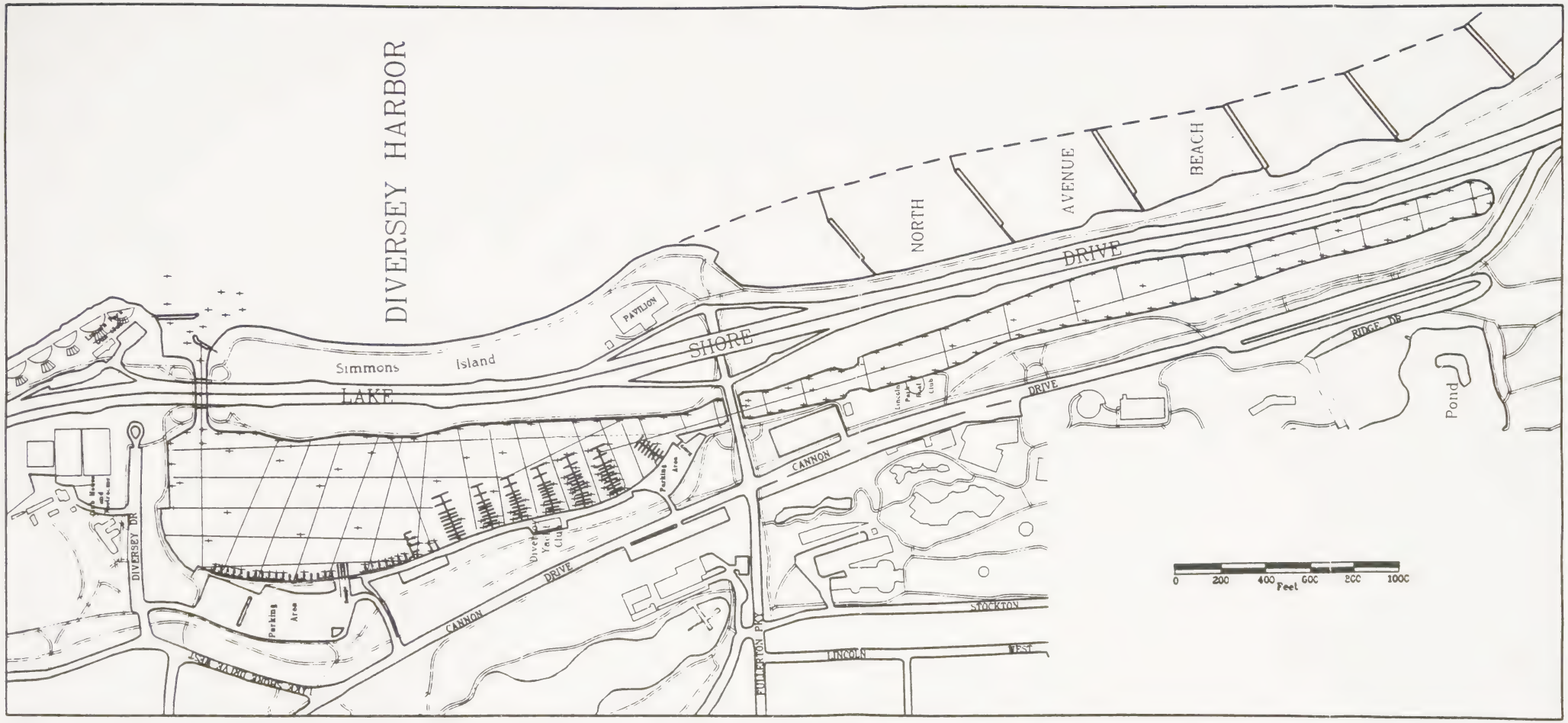


Figure 7. Bathymetric Profile Lines and Bottom Sample Locations:
Diversey Harbor, Chicago, Illinois

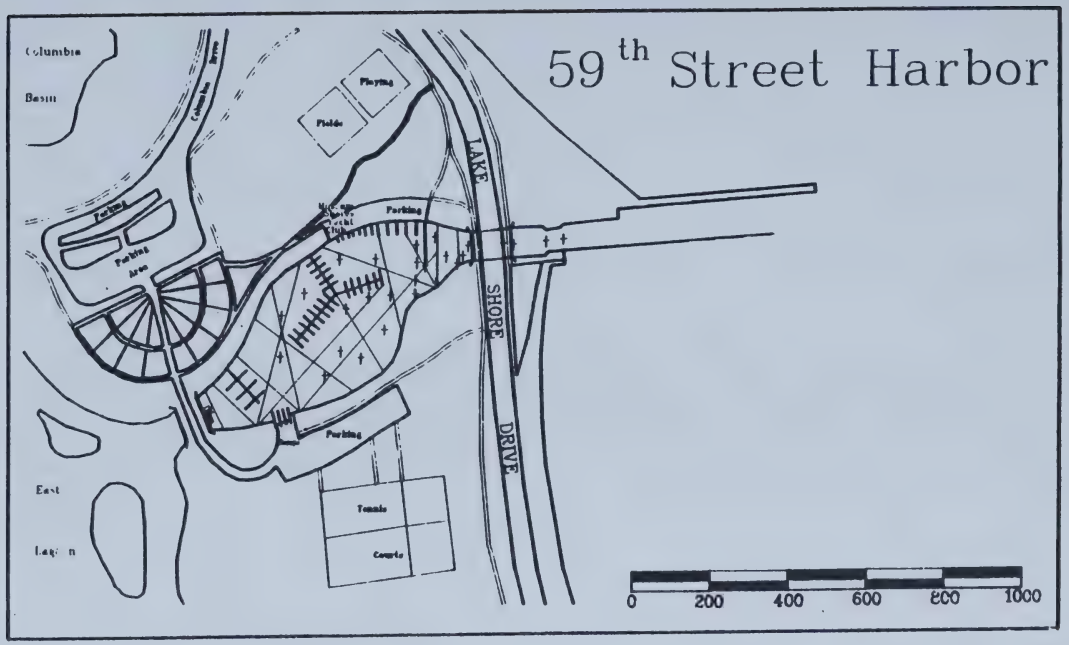


Figure 8. Bathymetric Profile Lines and Bottom Sample Locations:
59th St Harbor, Chicago, Illinois

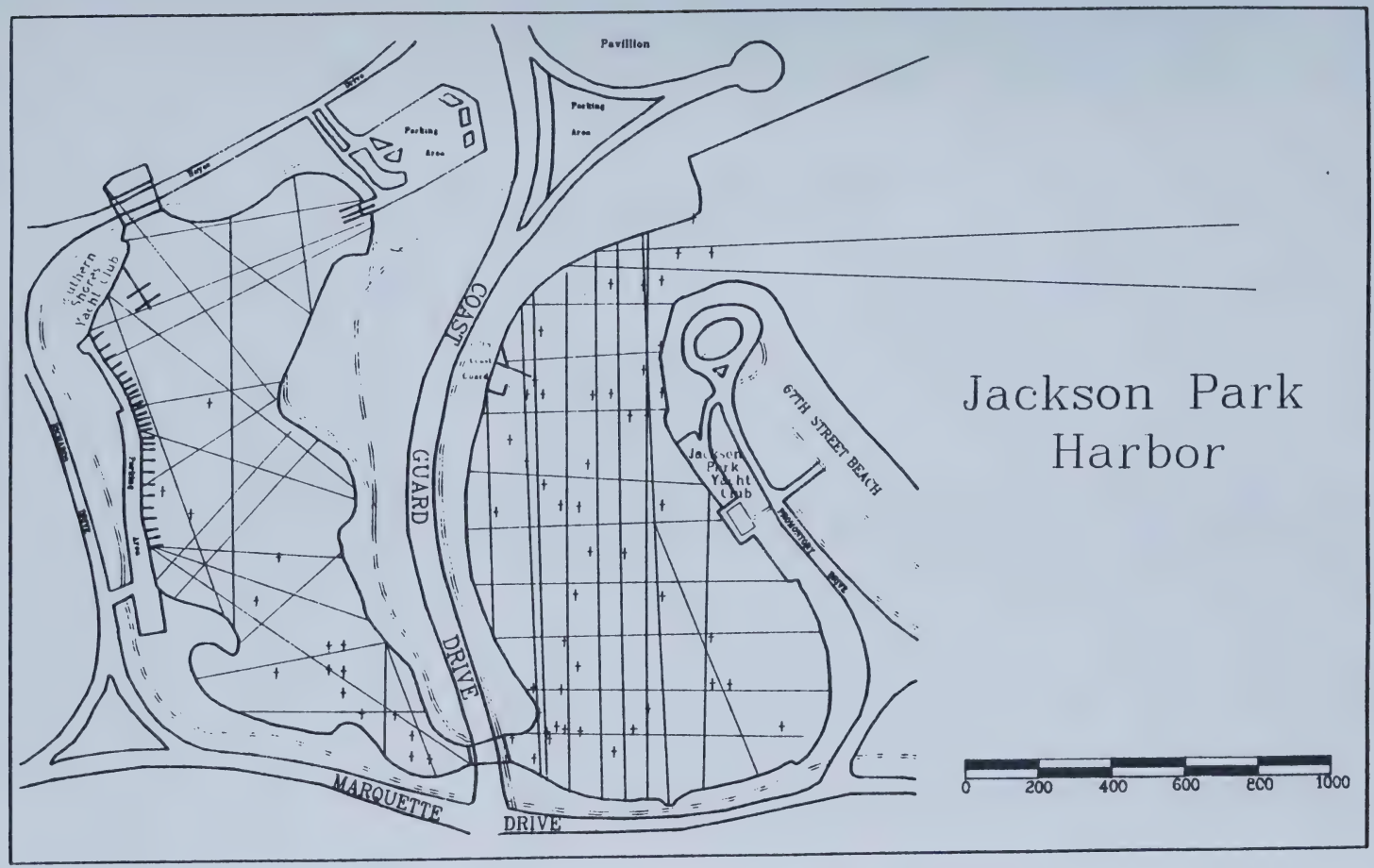


Figure 9. Bathymetric Profile Lines and Bottom Sample Locations: Jackson Park Harbor, Chicago, Illinois

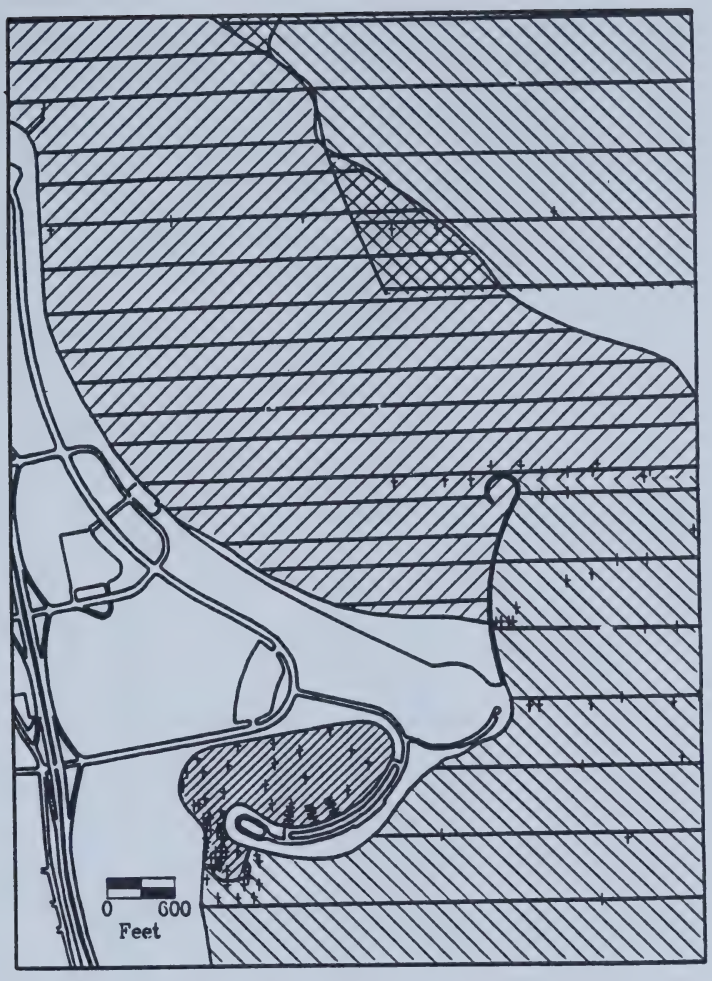
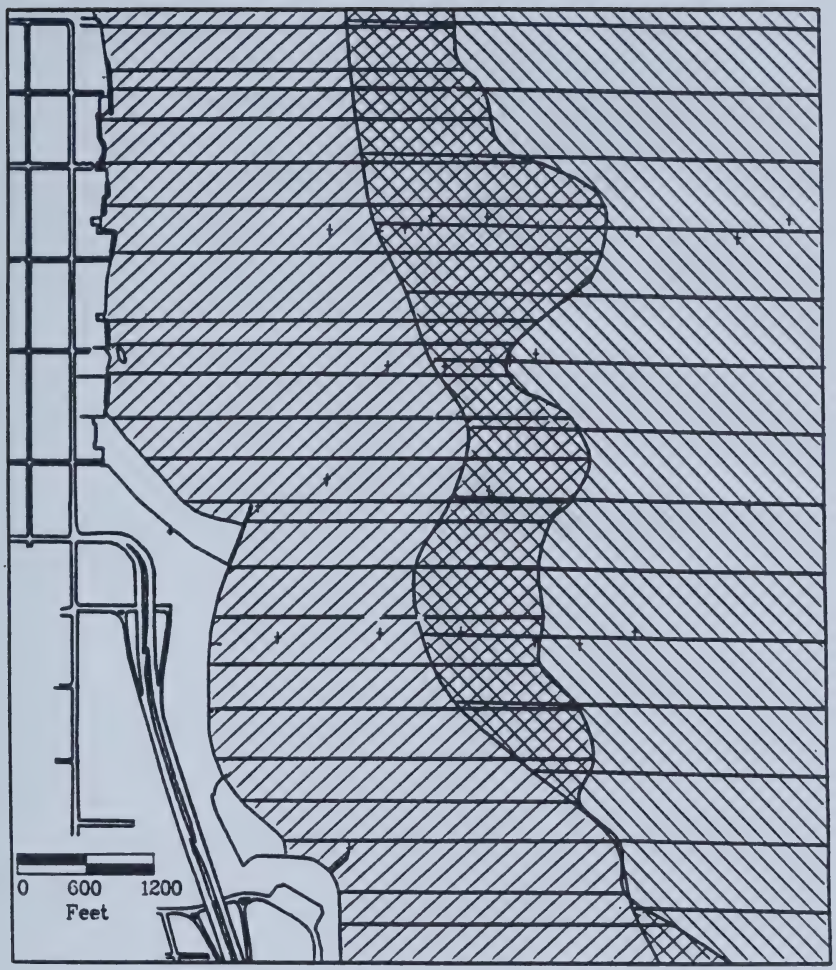

0
600
Feet
Bathymetric Data collected in April & November 1988
(ISGS/USGS Cooperative Project)
Bathymetric Data collected in July & August 1990
(ISGS/USGS Cooperative Project)
Bathymetric Data collected in July 1991
(IDOC Project No. F-112-R-1)
Petite Ponar Grab Samples collected in June & July 1991
(IDOC Project No. F-112-R-1)

Figure 10. Bathymetric Profile Lines and Bottom Sample Locations: Lincoln Park, Chicago, Illinois



Bathymetric Data collected in August 1990
(ISGS/USGS Cooperative Project)

Bathymetric Data collected in July 1991
(IDOC Project No. F-112-R-1)

Petite Ponar Grab Samples collected in July 1991
(IDOC Project No. F-112-R-1)

Figure 11. Bathymetric Profile Lines and Bottom Sample Locations: Edgewater District, Chicago, Illinois

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING
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APPENDIX B

Shore Features, Water Depths, and Bottom Materials Distribution:
Plate 6: Lincoln Park, Chicago, Illinois
Plate 7: Edgewater District, Chicago, Illinois

Illinois State Geological Survey
Champaign, IL 61820
August 1991

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING

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Dingell-Johnson/Wallup-Breaux
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APPENDIX C

Plate 8: Southwestern Lake Michigan
Map Showing Longitude/Latitude Grid, Bathymetry
and Bedrock Reefs

Illinois State Geological Survey
Champaign, IL 61820
August 1991

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APPENDIX D

Plate 9: Nearshore Areas: Illinois Beach State Park with Longitude/Latitude Water Depths and Outlines of Some Bottom Materials Distribution

Illinois State Geological Survey
Champaign, IL 61820
August 1991

APPENDIX E:
EQIUPMENT AND TECHNIQUES

EQUIPMENT

R.V. Alki - This boat is an 10-foot inflatable dinghy, outfitted with a 9.9 hp. Evinrude outboard engine. It was used for all bathymetric work prior to 1991.

R.V. Edgewater - This 19-foot fiberglass-hulled Zodiac Hydropro boat with and inflatable collar was the primary workboat for the 1991 field season. It is equipped with twin outboard 28 hp. Evinrude engines, VHF radiotelephone, twin Apelco LORAN-C navigation devices, digital fathometer, 200-lb. capacity winch for dredging capability, electronic distance meter target and mount for total station prism arrays. It is fully equipped for all aspects of mapping done in this study.

Ross 100 kHz Model 803 Hydrographic Survey Chart Recorder - This device measures depths using an acoustic transponder. The analog printed readout gives permanent records of bathymetric profiles. This readout is graduated in 1-foot intervals, but can be read to ±0.1 foot using a scale. The depth readings are calibrated before each use by measuring water depths with a graduated stadia rod.

Apelco DXL 6300 LORAN-C Positioning System - Twin Apelco LORAN-C receivers provide positioning in many circumstances. They readable to 1/100th of a minute, or ± 30 feet longitude and ± 23 feet latitude, giving a maximum positional error of ± 38 feet. The readouts are calibrated daily by towing or driving the boat to a known location, either a City of Chicago surveyed monument or other measures location, and correcting the LORAN-C readout to that of the known location. It was found that a consistent calibration factor was generally required along each part of the Illinois shoreline (northern, center, or southern). End-of-day readings on the same locations showed that the calibration did not drift during the day.

Sonin Electronic Distance Meter - This hand-held electronic distance meter uses infra-red and acoustic signals between the base unit and an electronic target to measure distances up to 350 feet with 99% accuracy, according to product literature. The readout is in feet and inches, with fractions displayed to 1/8 inch.

Motorola Mini-Ranger Falcon III Microwave Ranging System - This system uses microwave signals to measure distances between a shore transponder and the base station on board the boat. Product literature claims an accuracy to ± 3 meters (about 10 feet), with a readout which displays to whole meters.

Lietz SDR24 Set 4 Total Station - The total station is a combined transit and electronic distance meter, which was used in land surveys of the mapped areas. It displays angles to a precision of 5 seconds, and display distances to 1/100 of a foot. This would produce and error of up to 0.2 feet per 8000 feet of distance. Maintenance, calibration, and use of the total station follows procedures outlined in product literature.

PROCEDURES

Base Map Production and Adjustment

USGS 7.5-minute quadrangles were digitized as original base maps used for the products in this study. Land surveys used in adjusting the maps were done to third-order accuracy (1/5000 closure accuracy). In map processing, accuracy in computer digitizing within the area bounded by control points is +/- 2.5 feet. Lack of perfect registration in transferring data onto map sheets reduces that accuracy to +/- 5 feet.

Bottom Materials Sampling

The majority of bottom samples were collected during 1991 from the R.V. Edgewater. A Petite Ponar dredge was used to collect bottom samples up to approximately 1 liter in volume. The samples were textually described in the field, bagged, and returned to the laboratory for microscope analysis of texture and composition. A 10x binocular microscope and comparative grain-size slides were used to estimate the major and minor fractions of each sample, as well as to identify other constituent materials such as organic matter. Size fractions were classified according to the modified Wentworth scale (Wentworth, 1922) as: clay (<.002 mm), silt (.002 mm to .064 mm), fine sand (.064 mm to .250 mm), medium sand (.250 mm to .500 mm), coarse sand (.500 mm to 2 mm), gravel (2 mm to 64 mm), cobbles (64 mm to 250 mm), and boulder (>250 mm).

Bottom samples were located on base maps by field estimation in small harbors, where proximity to mapped landmarks provided easy and rapid position estimation. In other locations, LORAN-C readings were recorded during sampling. Positions were plotted on maps containing a 1/10th minute latitude/longitude grid. Boundaries of bottom materials were delineated and digitized along with sample locations to update the computer data base for printing finished copies of each map.

Bathymetric Mapping

Prior to 1991, bathymetric mapping utilized the R.V. Azki, which was equipped with a Ross 803 Hydrographic Survey Chart recorder and a Motorola Mini-Ranger navigation system. The traversed a survey line, kept within ± 5 feet of that line by a transit operator. Offshore distances as determined from the Mini-Ranger readout were marked on the chart recording at regular intervals so that the offshore distance at any point along the bathymetric profile could be interpolated. Water surface elevations were determined from hourly measurements at the National Ocean Service Calumet Harbor Lake Gauge, then revised to a standard level, Low Water Datum, (LWD) at 576.8 feet above sea level, International Great Lakes Datum (IGLD). Water depths were then measured directly from each standardized depth chart record where that bottom profile crossed each whole foot increment, so that a data set of offshore distances and whole foot depth increments was produced for each bathymetric profile. Location errors for each depth measurement are calculated to be ± 16 feet; angular error from the transit is calculated to be a maximum of ± 13 feet at an offshore distance of 2500 feet, and the offshore distance measurement is accurate to ± 10 feet.

1991 bathymetric data were provided in a similar fashion, but LORAN-C provided navigation and positional control. Bathymetric profiles were recorded along lines of latitude at 1/10th minute intervals The LORAN-C location of the

beginning and end points of each line were marked, as well as each 1/10th minute line of longitude along each profile. Using this method, location errors for each depth measurement are the same as those for LORAN-C navigation as discussed previously, ± 35 feet. Each bathymetric data set was mapped on base maps, contoured at a 1-foot depth interval, then digitized into the computer data base.

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APPENDIX B

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Plate 6: Lincoln Park, Chicago, Illinois
Plate 7: Edgewater District, Chicago, Illinois

Illinois State Geological Survey
Champaign, IL 61820
August 1991

Illinois State Geological Survey
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820

Address Correction Requested

PLATE 7

EXPLANATION

Beach Sand

Sand & Silt

Cobbles & Boulders (Including Toe Protection)

Silt

Gravel

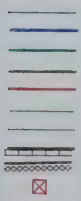
Silt & Clay

Sand & Gravel

Clay

Sand

Glacigenic Clay (Glacial Till) with Sand, Gravel, Silt, Cobbles & Boulders Often Covered by Thin, Patchy Sediments Derived from the Till


Contours in Feet Below Low Water Datum (576.8 feet IGLD)
Index Contours (Every 5 Feet)
1990 Shoreline
Shore Protective Structures
Streets, Boulevards, Highways and Parking Areas
Walkways, Bicycle Paths and Playing Fields
Selected Cultural Features
Stepped Stone Revetment
Riprap Revetment
Surveyed Vertical Profile Locations (1990)

EXPLANATION

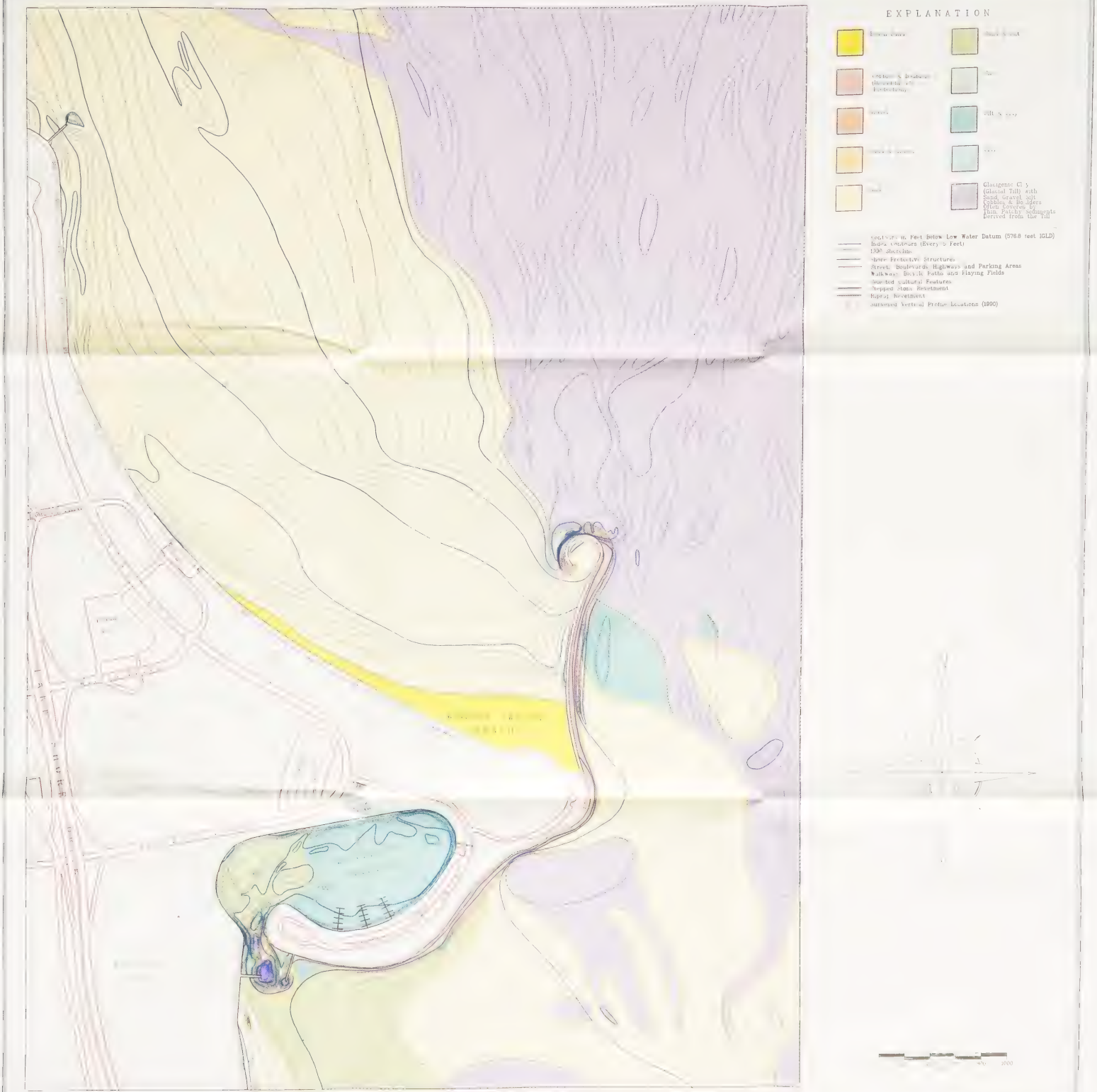
- Beach Sand
- Sand & Silt
- Cobbles & Boulders (Including Toe Protection)
- Silt
- Gravel
- Silt & Clay
- Sand & Gravel
- Clay
- Sand
- Glacigenic Clay (Glacial Till) with Sand, Gravel, Silt, Cobbles, & Boulders Often Covered by Thin, Patchy Sediments Derived from the Till

Contours in Feet Below Low Water Datum (576.8 feet IGLD)
Index Contours (Every 5 Feet)
1956 Shoreline
Shore Protection Structures
Streets, Boulevards, Highways and Parking Areas
Walkways, Bicycle Paths and Playing Fields
Selected Cultural Features
Stepped Stone Revetment
Riprap Revetment
Surveyed Vertical Profile Locations (1990)

DRAFT EXAMPLE OF MAP AVAILABLE IN LARGER SIZES

EDGEWATER DISTRICT EDIS[illegible] [illegible]

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION


EXPLANATION
Glaciogenic Clay (Glacial Till) with Sand, Gravel, Silt, Pebbles, & Boulders Often Covered by Thin Patchy Sediments Derived from the Till
Contours in Feet Below Low Water Datum (576.8 feet IGLD)
Index Contours (Every 5 Feet)
1990 Shoreline
Shore Protective Structures
Street, Boulevards, Highways and Parking Areas
Walkways, Bicycle Paths and Playing Fields
Selected Cultural Features
Stepped Stone Revetment
Riprap Revetment
Surveyed Vertical Profile Locations (1990)

DRAFT EXAMPLE, Available in Larger Sizes

SHORE FEATURES, WATER DEPTHS AND BOTTOM MATERIALS DISTRIBUTION

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING

Illinois Department of Conservation
Dingell-Johnson/Wallup-Breaux
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APPENDIX C

Plate 8: Southwestern Lake Michigan
Map Showing Longitude/Latitude Grid, Bathymetry
and Bedrock Reefs

Illinois State Geological Survey
Champaign, IL 61820
August 1991

inois State Geological Survey
atural Resources Building
5 East Peabody Drive
ampaign, IL 61820

dress Correction Requested

SOUTHWESTERN LAKE MICHIGAN

Kenosha

WISCONSIN
ILLINOIS

North Point Marina

Zion

Waukegan Harbor

Waukegan

North Chicago

Great Lakes Harbor

Lake Bluff

Lake Forest

Fort Sheridan

Highland Park Reef

Lake Bluff
Reef

Winnetka Reef

Northwestern Reef

Montrose Harbor

Belmont Harbor

Uptown
(Chicago)

Diversey Harbor

Chicago Harbor

Jackson Park

South Park Harbor

Calumet Harbor

Calumet Harbor

Indiana Harbor

ILLINOIS
INDIANA

Bedrock reefs

Questionable reefs

N

Contours in Feet Below Low Water Datum (1985 feet IGLD)

Scale 1:120,000

0 3 6

Miles

Legend

- Bathymetric contours and shoreline
- rivers and small lakes
- streets and highways
- railroads
- state boundaries

Chart prepared from digital data by James R. Jennings and Robert A. Lambert, Fishmap Special Investigations , Illinois State Geological Survey, 1991
Bathymetric contours and reefs digitized by Robert A. Lambert
Nearshore features digitized by P. D. Terpstra and J. R. Jennings from U.S.G.S. quadrangle maps and from aerial photography by I.D.O.T. Grid lines prepared by J. R. Jennings

Draft Example, Available in Larger Sizes

LITTORAL ZONE HABITAT CLASSIFICATION AND MAPPING

Illinois Department of Conservation
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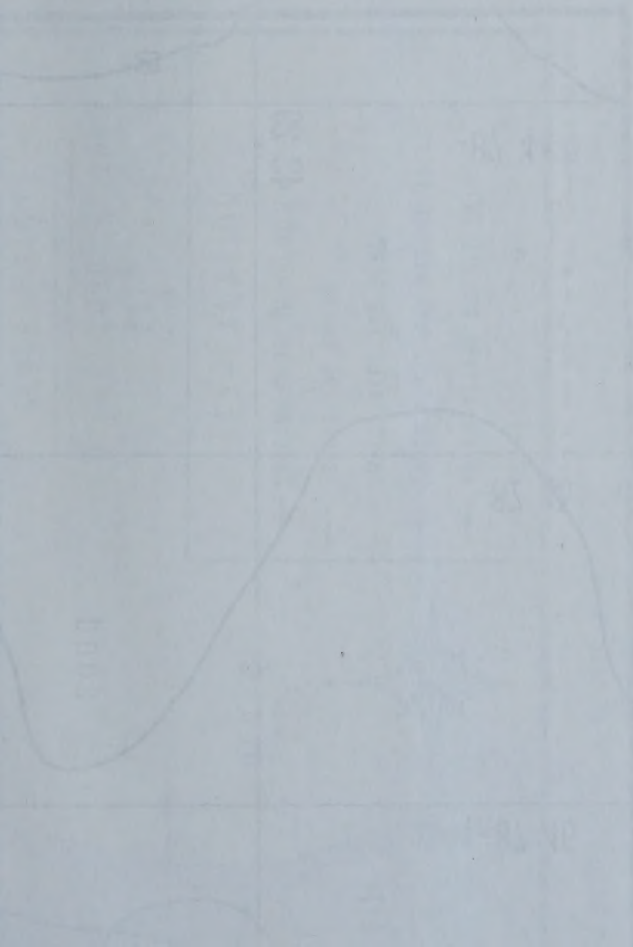
APPENDIX D

Plate 9: Nearshore Areas: Illinois Beach State Park with Longitude/Latitude Water Depths and Outlines of Some Bottom Materials Distribution

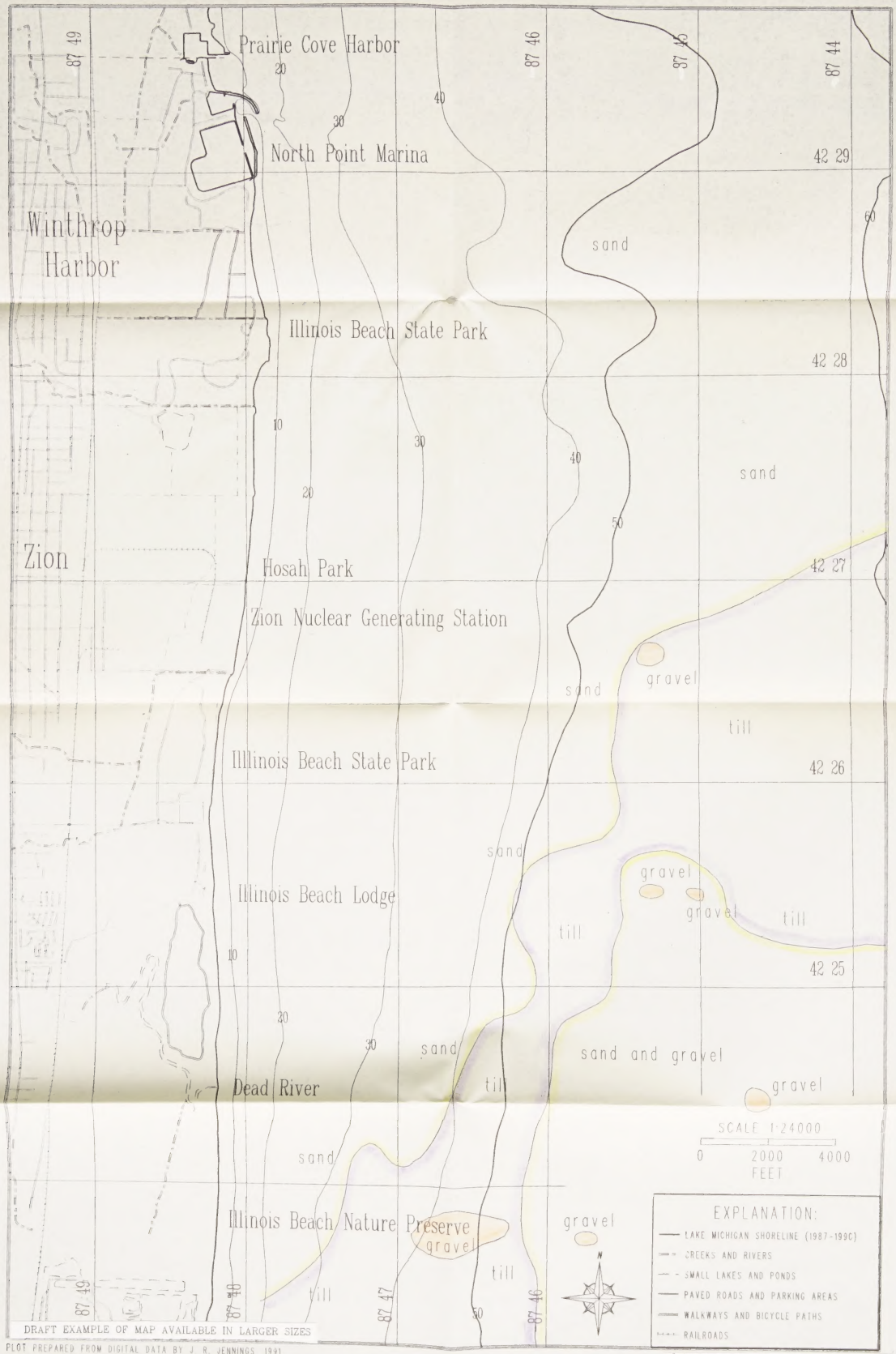
Illinois State Geological Survey
Champaign, IL 61820
August 1991

Illinois State Geological Survey
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820

Address Correction Requested



NEARSHORE AREAS: ILLINOIS BEACH STATE PARK



DRAFT EXAMPLE OF MAP AVAILABLE IN LARGER SIZES

PLOT PREPARED FROM DIGITAL DATA BY J. R. JENNINGS, 1991.
BOTTOM SEDIMENT DATA COMPILED FROM R. D. NORBY AND C. COLLINSON, 1977; G. S. FRASER AND N. C. HESTER, 1974; J. B. GRAF, 1976; L. H. SOMERS AND P. D. JOSEPHSON, 1968; AND C. J. WELKIE, 1980.
BASE MAP DIGITIZED BY J. R. JENNINGS AND P. D. TERPSTRA, 1987 - 1990. MODIFIED FROM THE ZION QUADRANGLE USING AERIAL PHOTOGRAPHY BY I.D.O.T.
LAND SURVEY DATA BY J. R. JENNINGS, P. D. TERPSTRA, R. B. MATTHEWS, AND J. J. MINER. LATITUDE/LONGITUDE GRID BY J. R. JENNINGS.
BATHYMETRY COMPILED, CONTOURED, AND DIGITIZED BY R. A. LAMBERT.
NEARSHORE CONTOURS MODIFIED FROM C. COLLINSON AND R. D. NORBY AND P. D. TERPSTRA. DEEPER WATER CONTOURED BY R. A. LAMBERT FROM DATA BY N.O.S.

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